MANAGEMENT OF POST-HARVEST LOSSES BY FARMERS' DURING MARKETING OF VEGETABLE CROPS IN THE STATE OF HIMACHAL PRADESH

Thesis

by

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CERTIFICATE-I

This is to certify that the thesis titled **"Management of Post-Harvest Losses by Farmers' during Marketing of Vegetable Crops in the State of Himachal Pradesh"** submitted in partial fulfillment of the requirements for the award of the degree of Doctor of Philosophy **Agri-business Management** in the discipline of **Agri-business Management** to Dr. Yashwant Singh Parmar University of Horticulture & Forestry, (Nauni) Solan (HP) - 173 230 is a bonafide research work carried out by **Ms. Priyanka Sharma** daughter of Shri Umesh Dutt under my supervision and that no part of this thesis has been submitted for any other degree or diploma.

The assistance and help received during the course of this investigation has been fully acknowledged.

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CERTIFICATE-II

This is to certify that the thesis titled, **"Management of Post-Harvest Losses by Farmers' during Marketing of Vegetable Crops in the State of Himachal Pradesh"** submitted by **Ms. Priyanka Sharma (ABM-2020-03-D)** daughter of Shri. Umesh Dutt to the Dr. Yashwant Singh Parmar University of Horticulture and Forestry, (Nauni) Solan (HP) - 173 230 India in partial fulfilment of the requirements for the degree of **Doctor of Philosophy Agri-business Management** in the discipline of **Agri-business Management** has been approved by the Advisory Committee after an oral examination of the student in collaboration with an External Examiner.

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ABBREVIATION USED

%	:	Per cent
&	:	And
∑	:	Summation
amsl	:	Above mean sea level
APMC	:	Agricultural Produce Market Committee
Approx	:	Approximate
CAGR	:	Compound annual growth rate
Coeff	:	Coefficient
df	:	Degree of freedom
et.al	:	Co-workers
etc	:	et cetera
FAO	:	Food and agricultural organization
Fig	:	Figure
Ha	:	Hectare
HP	:	Himachal Pradesh
i.e.	:	That is
km	:	Kilometer
KMO	:	Kaiser Meyer Olkin
KVK	:	Krishi Vigyan Kendra
m	:	Meters
M.T	:	Million Tonnes
mm	:	Millimeter
N	:	Number of the respondents
^oC	:	Degree Celsius
OPR	:	Ordered probit regression
PC	:	Principal Component
PCA	:	Principal Component Analysis
PHH	:	Post-harvest handling
PHL	:	Post-harvest Loss
PHM	:	Post-harvest management
R^2	:	Coefficient of determination
RII	:	Relative importance index
Rs	:	Rupees
SD	:	Standard deviation
SE	:	Standard error
Sig	:	Significance
SPSS	:	Statistical Package for Social Sciences
Sq. km	:	Square kilometer
Sr. No.	:	Serial Number
Stata	:	Statistics and data
UHF	:	University of Horticulture and forestry
VIF	:	Variance Inflation Factor

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Chapter-1

INTRODUCTION

Agriculture is the backbone of income for almost 60 per cent of India's population. Those who live in rural areas depend on agriculture both directly and indirectly for their livelihood (Reddy *et al.*, 2019). Agriculture and allied sector increase at a positive growth rate of 3.6 per cent in 2020-21, 3.9 per cent in 2021-22 and contribute 18.8 per cent of the country's Gross Value Added (GVA) in 2020-2021 (Anonymous, 2021). The overall production of food grains was predicted to be 296.65 Million Tonnes in 2019-20. India is the second largest producer of fruits and vegetables. India produced 204.61 million metric tonnes in 2021-22, with 11.28 million hectares of vegetables under cultivation (APEDA, 2022-23). In horticulture sector, vegetables are an important crop that occupies an area of 90.94 thousand hectares with a total production of 19.36 lakh tonnes and average productivity of 21.29 tonnes/hectare in Himachal Pradesh (HP DoA Annual Report, 2021-2022).

According to National Commission on Agriculture (XII Report, 1976), Agricultural marketing is a process, which starts with a decision to produce a saleable farm commodity, involves all the aspects of market structure or system, both functional and institutional, based on technical and economic considerations, and includes pre and post- harvest operations, assembling, grading, storage, transportation and distribution (Acharya and Agarwal, 2021).

Horticulture has evolved as a major economic activity throughout Asia and the Pacific, encompassing the production of fruits, vegetables, flowers, spices, medicinal, fragrant plants, and plantation crops. Simultaneously, advances in science and technology may present an opportunity to increase horticultural produce production (Choudhary, 2006). Vegetables are crucial for food and income for farmers, contributing to food safety and poverty reduction. With population growth and land disintegration, vegetables are a viable alternative due to their higher productivity per unit area. Vegetables solve food and nutritional challenges and have potential for internal and distributed markets. The country's vegetable production has increased from 15 million tons before independence to 90 million tons (Singh, 2002). Most vegetable production is seasonal and extremely confined to take advantage of the country's agro-climatic characteristics (Garikai, 2014).

Over the last few decades, India's agriculture has grown at a rapid pace. The wastage of agricultural commodities would result in not just monetary losses, but also economic instability and a drop in already low nutritional standards in developing countries (FAO, 1980). Before reaching the consumer, all agricultural commodities must go through a series of activities such as threshing, transportation, processing, storage, and exchange. There are significant losses of outputs at these stages of their handling. The total amount of outputs lost in these activities at all of these stages is referred to as Post-harvest losses (Kumar *et al.*, 2006). Although there is little research on the impact of postharvest losses on household food insecurity, postharvest loss reduction may have a significant impact on food, nutritional, and financial stability for many rural households (Garikai, 2014).

Postharvest losses are a significant issue, despite significant spending on plant culture, irrigation, fertilizers, and crop protection measures. Despite this, little attention is given to these losses, leading to a failure to meet the food needs of millions of hungry people, despite the significant resources and time spent on these measures (FAO, 1980). Apart from being too expensive for postharvest distribution chain operators, most extension projects done in underdeveloped countries were short-term and primarily focused on large-scale commercial horticulture firms (Kitinoja *et al.,* 2011). Participants in postharvest training may have expressed an interest in implementing improved postharvest handling and technologies, but they are unable to do so since the requisite equipment and tools are not available locally (Sabuddin, 2017).

Approximately 80 per cent of Indian farmers are small and marginal, post-harvest losses have a first-order effect on them. In India, limited storage facilities force smallholder farmers to sell their produce at low rates soon after harvest, in addition to post-harvest losses (Parfitt *et al.*, 2010). Improper storage contributes to low farmer income and seasonal food deficiencies, while empowering farmers through market choice can diminish intermediaries' stranglehold and improve storage facilities and PHM (Boss and Pradhan, 2020).

Food loss after harvest is defined as measurable qualitative and quantitative food loss along the supply chain, from harvest through consumption or other end uses (Hodges *et al.*, 2011). Post-harvest losses estimates remain consistent with earlier estimates, despite 1974's recognition of them as part of global hunger solutions. Current research suggests 15% of grain may be lost in this system (Liang, 1993).

India's farmers face a 63,000 Crore annual loss due to inability to sell 40% of their produce, a significant issue due to lack of advanced harvesting equipment, collection centers, and ignorance among producers, middlemen, and consumers (Singh, 2002). Post-harvest losses, a significant portion of vegetable production, were prevalent in underdeveloped nations, ranging from 5-25%, due to inadequate processing, transportation, and storage (Kader, 2005).

The estimated farming area for vegetables in Himachal Pradesh is over 90,000. Up to 50 per cent of vegetables produced in developing countries are lost in the supply chain between harvest and consumption. In Himachal Pradesh the total numbers of land holdings are 933383 out of which 636619 are marginal farmers and 175651 are small farmers'. Reduction in post-harvest losses is one of the ways to increase income of smallholder farmers' (Babalola *et al.*, 2010). Despite the breakthrough in production, insufficient and unscientific post-harvest handling of fruits and vegetables has resulted in a post-harvest loss of roughly Rs. 30 Billion per year (20-40 per cent). To avoid these losses, every effort must be made (Reddy *et al.,* 2019).

Post-harvest losses are primarily due to environmental factors, inadequate sanitation, and poor cooling and environmental management. The lack of a modern supply network, particularly cold chains, has hindered the world's largest producer from fully utilizing its power for exports or processing. The establishment of a cold chain is hindered by a lack of viability and support structure, including human capital, quality benchmarks, and food protocols (Meena *et al.*, 2009).

The vegetable sector plays a vital role in farm income enhancement and reduction of poverty in many developing countries. However, this sector suffers greatly from the problem of high postharvest losses, resulting in significant declines in food quality and safety, competitiveness in the market, and profits earned by producers (Ali, 2012). Post-harvest losses can occur in various sectors like field, packing, storage, transportation, wholesale and retail markets due to inadequate facilities, lack of knowledge, poor management, improper market facilities, or careless handling by farmers, intermediaries, and consumers. It is important that the post-harvest practices be given as much attention as production practices (Kumar *et al.*, 2006). The use of appropriate postharvest technologies and procedures reduces quantitative losses, slows deterioration, and maintains quality and safety of commodities (Kader, 2005).

Vegetable farming in the state is hindered by inadequate post-harvest management practices, leading to low output and high vegetable rotting rates. Inadequate harvesting, shipping, storage, and marketing practices, along with inadequate legislation, create secondary causes of loss. A perfect marketing strategy is needed to reduce losses, ensure availability, and earn a decent return on investment. During peak season, wastage and low prices can discourage farmers, requiring extra effort to avoid overeating and weight loss (Yahaya and Mardiyya, 2019).

The government has introduced guidelines to offer a 50% subsidy for storing and shipping fruit and vegetables within a set timeframe, aiming to reduce post-harvest losses and create employment in rural areas (Patil and Singh, 2007). Post-harvest management is crucial in the evolving global landscape, preventing significant losses and ensuring monetary returns in countries like India (Meena *et al.*, 2009).

Himachal Pradesh, a North-Western state with a rural population of 89.96%, offers diverse agro-climatic conditions for crop cultivation. Agriculture is the primary source of income for the people of Himachal Pradesh, contributing significantly to the state's economy. The state is also known for its large-scale production of fruits, making fruit and vegetable cultivation a significant source of income for farmers (Pathania, 2022). The state's farming community spans 9.99 lakh hectares, managed by 8.63 lakh farmers, out of a total of 55.673 lakh hectares (Statistical Abstract of Himachal Pradesh, 2022). Small and marginal farmers possess around 84.5% of the state's agricultural land, and their ability to expand their cultivable land base is constrained. Adopting management techniques to lower post-harvest losses and diversifying toward high-value crops should be the primary objectives in order to boost production. The post-harvest losses of vegetables are influenced by several variables. Significant losses occur between harvesting and consuming as a result of these causes.

The study was carried out with specific objectives in consideration depending on the information presented:

1. To study the existing status of post-harvest losses during marketing of selected vegetable crops.

2. To identify factors affecting post-harvest losses of farmers' during marketing of vegetable crops.
3. To identify the key constraints and suggest management interventions for managing post-harvest losses during marketing of vegetable crops.

Need of the study

This study explores the significant issue of post-harvest losses in vegetable crops, acknowledging their impact on both farmer economic stability and food availability. The research attempts to identify the reasons influencing loss into handling practices, market dynamics, conditions of storage, and modes of transportation. Reducing postharvest losses in Himachal Pradesh is critical for preserving livelihoods, food security, and economic growth, as it aligns with national goals of increasing agricultural efficiency. The research gap in post-harvest losses in Himachal Pradesh is characterized by insufficient studies, market dynamics, and government policies. Also, previous studies has mostly examined the causes that contribute to post-harvest losses, but have not addressed the current management strategies employed by farmers for the reduction of post-harvest losses in vegetable crops. The study envisions a future in which improved post-harvest management approaches improve food security, farmer economic resilience, minimize environmental impact, and boost marketable surplus. To achieve these goals, it is crucial to analyze the current post-harvest loss scenario, identify the influencing factors, and identify the obstacles.

Limitation of the study

The investigation extends into Himachal Pradesh, revealing information that is specific to the region.

1. The research was conducted as a field survey. Despite our best efforts to obtain accurate information, there is a chance that part of the restriction was caused by respondents' willingness and recollection.
2. The study uses primary data from respondents to assess post-harvest losses. Generally famers were not maintaining any farm records and therefore, the results were only based on their experience and memory.

3. Due to time and financial constraints, the research only included 360 respondents from three in the district. The study's findings cannot be generalized, despite the researcher's best efforts.
4. The quality and nutritional value losses caused by post-harvest vegetable degradation are not taken into consideration in this study, unless the vegetable becomes unmarketable or inedible. These losses in the marketable stage should be taken into account in future studies.

Organization of the study

This study's work is organized into five chapters. The introduction, the need of and limitations of the study, the objectives, and the thesis strategy are all covered in this chapter. Chapter two contains the literature review. The third chapter covers the data gathering, analysis, and district and vegetable crop selection methods. The results and discussion of the problem are covered in the fourth chapter, which is divided into four sections: A, B, C, and D. The sampled respondent's socio-demographic profile was provided in Section A. Section B deals with the post-harvest losses in particular vegetable crops in particular Himachal Pradesh districts, as well as the growth rates in area, production, and productivity of the tomato, cabbage, and green pea crops. The elements influencing post-harvest losses at the market level are covered in section C. The limitations and recommended interventions for managing post-harvest losses in certain vegetable crops are covered in Section D. The study's key conclusions and their consequences for policy are outlined in Chapter 5. The list of references and appendices is provided at the end.

Chapter-2

REVIEW OF LITERATURE

A literature review is a thorough summary of earlier studies on a subject. The literature review examines scholarly books, journals, and other sources that are pertinent to a particular field of study. It provides a theoretical framework for the study. The literature review mentions earlier researchers' contributions. Knowing what knowledge and ideas have been formed on a subject, as well as their strengths and limitations, is the goal of creating a literature review. This chapter's Review of Literature section's goal is to provide an overview of the research that has been done on how police officers' work environments affect their levels of occupational stress and productivity. In light of this, it is discussed below;

2.1 To study the existing status of post-harvest losses during marketing of selected vegetable crops.

2.2 To identify factors affecting post-harvest losses of farmers' during marketing of vegetable crops.

2.3 To identify the key constraints and suggest management interventions for managing post-harvest losses during marketing of vegetable crops.

2.1 Existing status of post-harvest losses

Tadesse (1991) conducted a study on postharvest losses of fruits and vegetables. The main focus of the study was to estimate the post-harvest losses in developing countries like Ethiopia. In this study the author further identified the factors that affect the post-harvest losses of fruits and vegetables. The study revealed that around 25-35 per cent fruits and vegetables were lost during post-harvest practices. The study found that the horticulture produce loss happens in both pre and post-harvest but most produce loss during post-harvest practices. Factors that were responsible for the maximization of post-harvest losses were immature harvesting, improper transportation, packaging and storage system. The study recommended providing training to staff towards handling of produce, constructing necessary infrastructure such as evaporative cooler, pre-cooling units, cold storage etc. and strengthening marketing service and distribution network for minimizing the postharvest losses of horticultural crops. The study also suggested the adoption of modern technologies in minimizing the postharvest losses.

Olorunda and Aworh (1983) assessed a study on post-harvest losses of perishable vegetables in the Nigerian market. The study revealed that up to 20 per cent of vegetables were lost from the production area to the wholesale market during the transportation, storage, loading and unloading process of tomato and onion. The study concluded due to mechanical injury improper packaging, handling were the reason for post-harvest losses. The study suggested using specialized transportation methods such as refrigerators, insulated wagons etc. for perishable vegetable crops.

Viswanathan *et al.* (1998) conducted a study to estimate the postharvest losses of tomato in Tamil Nadu. The study used a survey method during crop season by making regular visits to the farmers' field, markets and various categories of traders. The study revealed from the survey method that pre-harvest losses occur up to 22 per cent in winter crops followed by 14 per cent in monsoon crops and 17 per cent in summer crops. The study further found at farm level postharvest losses for improved and hybrid varieties were 10.2 per cent and 8.7 per cent. Whereas, in local mandi's loss occurred 7-8 per cent and 6-7 per cent for improved and hybrid varieties. The study concluded that total postharvest losses for improved varieties were 32.8 per cent and for hybrid varieties 25.3 per cent whereas, at handling stage loss occurred 7-8 per cent for improved and 5-6 per cent for hybrid varieties. The study suggested reducing the number of handling in the market network for minimizing the postharvest losses of tomato.

Kumar *et al*. (2006) conducted a study in Karnataka on economic analysis of post-harvest losses in vegetables. The objective of this study was to estimate the extent of post-harvest losses at different stages in selective vegetables. The author also studies the factors that affect the post-harvest losses at the farm level. The study used the average and percentage method for the estimation of post-harvest losses and functional analysis was used for the identification of factors that affect the post-harvest losses in vegetables crops at the farm level. The study concluded that post-harvest losses at field level in selected vegetables was estimated to be 6.21 kg per quintal and losses occurring during packaging, handling of produce and marketing was estimated to be 12 kg per quintal. The study also found that factors such as adequate storage facilities, transportation and favorable weather conditions would help in minimizing the post-harvest losses. The study suggested that establishment of storage units would help in reducing the storage losses in vegetables as well as the technology developed by Indian Council of Agricultural Research i.e. zero energy coal chamber need to be popularized.

Gajanana *et al.* (2006) assessed a study on estimation of post-harvest losses of tomato crops. The main objective of this study was to assess the post-harvest losses at different stages of handling of tomato crops in Karnataka. The study concluded that around 19 per cent of tomato crop was reduced during post-harvest. The study further revealed that at field level the loss occurs around 9.43 per cent, followed by 4 to 5 per cent at market level and 5 per cent at retail level. The study also found the factors that affect the tomato crops at farm level was pest and disease whereas pressing, cursing of produce were the major causal factor of losses at market level of handling. At the retail level, losses occur due to secondary infection, over ripeness of fruits and pressing of produce during transportation, storage etc. The suggestion given by the study was that using integrated pest management, harvesting the produce at firm breaker stage and establishment of processing units in the production area can minimize the post-harvest loss of tomato and benefit the farmers. The study further recommended instituting tomato processing units in the production area for the reduction in tomato crop losses and also for the stabilization of the price.

Gajanana *et al.* (2011) reviewed a study on post-harvest losses in fruits and vegetables in South India. The objective of this study was to assess the post-harvest losses of fruits and vegetables. The study concluded that post-harvest losses in fruits and vegetables affected both producers and consumers. The study found that economic losses were determined to be up to 21.72 per cent, which was significantly less than physical losses. It was concluded from the study that harvesting of undersized and immature fruits were the major reason for the higher field level loss. The study suggested reducing the losses at farm level, farmers need to follow optimum maturity standards for harvesting of fruit and vegetables and recommended pre harvest practices such as use of harvester, integrated pest management and spray to reduce post- harvest losses. The study further recommended establishment of proper marketing infrastructure at the local and distant market levels that would reduce the post-harvest losses in fruit and vegetables which increase the income of the producers.

Sharma and Singh (2011) conducted a study on economic analysis of post- harvest losses in marketing of vegetables. The objective of this study was to assess the extent of post-harvest losses from production to consumption stage. The study found that at producer level maximum post-harvest losses occur in tomato followed by French bean, brinjal, pea etc. and at retail level maximum losses occur in tomato followed by okra, chilly and pea. The study revealed that across the different levels, the maximum loss found at grower levels in all the vegetables except capsicum. The study concluded that the main cause of post-harvest losses was harvesting of produce at inappropriate maturity, inappropriate infrastructure and storage facility, improper grading and packaging and inadequate transportation facilities. The study suggested the establishment of producer cooperatives for production and marketing activities which increase the bargaining power of growers. It was further recommended for the urgent need of the training programmes on scientific post-harvest techniques to the vegetable growers for the reduction of post-harvest losses in fruits and vegetables.

Mitrannavar and Yeledalli (2014) conducted a study on estimation of post-harvest losses of major vegetables such as potato, tomato, brinjal and beans in Karnataka. The study found that the largest loss was discovered at the level of commission agent-cum-wholesaler where the overall loss occurring in potatoes at different stages was around 22.86 per cent. For tomato crops the loss occurs around 27.445 per cent and for brinjal the loss occurs around 21.61 per cent where the maximum loss is found at retail level. For beans, crop loss occurs around 22.36 per cent where maximum loss is found at the level of commission agent-cum-wholesaler. The study suggested that losses which occur during harvesting and handling can be reduced by using effective technology for quality produce. There is also a need to build and develop organized markets, particularly for fruits and vegetables, based on geographical concentration, markets, consumption hubs, and other factors, in order to facilitate the procurement, storage, transportation, and processing of fruits and vegetables, which can help growers to promote a healthy market and economy.

Kalidas and Akila (2014) investigated the post-harvest losses of tomato at various stages of handling in Coimbatore district of TamilNadu. The study used simple average and percentage methods for the estimation of post-harvest losses at various stages of handling. The study concluded that around 13 to 26 per cent post-harvest losses occur from farm gate to consumers in tomato crop. It was concluded that at farm level the loss occurs around 6-7 per cent due to the harvesting injury, pest and disease infection whereas the loss occurs at wholesale level around 6 per cent due to improper packaging material, lack of transportation and infrastructure facilities. The losses estimated at retail level around 8 per cent and the main cause of loss was physical injury of tomato crops. The study found that post-harvest losses were reduced by eliminating market intermediaries. The study also suggested improving storage facilities and proper handling of produce that could reduce the post-harvest losses of tomato. The study further recommended that government should take effective step to sell farmers' produce directly to the consumers which increase the farmers; income level

Kiaya (2014) conducted a study on post-harvest losses and strategies to reduce post-harvest losses. The study found that both internal factors such as harvesting, handling, transportation, storage, marketing etc. and external factors such as environmental and socio-economic factors were contributing to post harvest losses. The study also found that with improved post-harvest practices, technologies, good storage management and improvement in storage hygiene could reduce post-harvest losses. Lastly, study suggested improving the quality and quantity of food crops, systematic analysis of each commodity production and handling system was the most important step for reducing post-harvest losses.

Munhuweyi *et al.* (2015) assessed the incidence of postharvest losses of cabbage at retail purchase and during consumer simulated storage. The study found that cabbage losses at the point of purchase varied from 13 to 30 per cent, with an average of 21 per cent and 50 per cent of the retail losses were caused by severe mechanical damage. The study even focused that rough handling during harvesting, loading, and unloading of produce might result in mechanical damage. The study put forth that mechanical bruising and cracks have evolved into degradation on day 7 of storage, particularly for ambient stored vegetables. The losses for optimal with 22 per cent and ambient storage with 34 per cent had increased. The study suggested these losses amounted to more than 10 million (US$1 million) every year, while the wasted fresh water was estimated to be enough to cover the needs of more than 217,000 people per year.

Affognon *et al.* (2015) conducted a meta-analysis that was carried out to reveal the nature and scope of post-harvest losses as well as the types of interventions that have been done to reduce the post-harvest losses. The study found that economic losses were more often than physical product losses. The study concluded that for the assessment of post-harvest losses, systematic methodology as well as holistic loss mitigation approaches was required. The findings revealed that there was a need to change the way in which post-harvest research has been conducted.

Underhill and Kumar (2015) reported a case study on quantifying postharvest losses along a commercial small holder tomato supply chain in Fiji. The study concluded around 32.9 per cent of harvested produce was removed due to rots (8.8 per cent), failure of ripen (8.9 per cent), insufficient volume fill a carton (7.8 per cent) and physical damage during storage (0.1 per cent), transportation (6.4 per cent) from commercial supply chain of tomato. The study also found that on-farm poor temperature management and limited postharvest hygiene were key contributors for postharvest losses of tomato. The study suggested use of appropriate technology, storage conditions and temperature can reduce the postharvest losses of tomatoes.

Kumari *et al.* (2015) conducted a study on economic analysis of postharvest losses of major fruits and vegetables along with future demand in Bihar. The study found that 22 to 30 per cent of fruits, 39 per cent of tomato and 18 to 22 per cent of cauliflower were lost during postharvest. The study analyzed that demand for fruits and vegetables would increase around 17464.42 Thousand MT (Million Tonnes) for vegetables and 6549.16 thousand MT for fruits in the year 2031. The study concluded that due to postharvest losses availability would be declined. The study suggested efficient postharvest management would increase the availability of fruits and vegetables through proper and developed infrastructure.

Sharma (2016) conducted a study on economic analysis of post-harvest losses in onions. The study found that at producer level 23.96 kg/q losses occur due to lack of storage facility, inadequate transportation, improper handling of produce during marketing, rotted bulks, improper packing and at farm level 28.99 kg/q losses identified. The study also observed some losses at wholesale and retail level i.e. 2.72 kg/q and 2.31 kg/q. The study concluded that most of the losses occur during storage time at farms. The study suggested that providing knowledge, training to vegetable growers on scientific post-harvest techniques for post-harvest management and to reduce post-harvest losses was an urgent need of farm level storage.

Talathi *et al.* (2016) assessed a study to estimate the postharvest losses in marketing of tomato in Karnataka. The study found that higher postharvest loss was estimated through producer-commission agent-wholesaler-retailer-consumer and lowest postharvest loss found through producer-consumer channel. The study concluded that the main constraints that tomato growers faced during marketing were commission charges, high transportation charges, wide-price fluctuation, lack of market information, non-availability of cold storage facility and labor in time. The study further suggested the government should provide cold storage and transportation facilities and market functionaries to reduce the postharvest losses during the tomato season.

Kumari *et al.* (2016) conducted a study on economic analysis of post-harvest losses of fruits and vegetables in Bihar. The study found total estimated losses was about 55046 MT for vegetables and 16539 MT for fruits respectively. The study suggested post-harvest management through proper infrastructure development. The study further recommended promoting processing of fruits and vegetables for value addition that would increase productivity and reduce the post-harvest losses of fruits and vegetables.

Ghazal *et al.* (2017) conducted a study to estimate the extent of postharvest losses or damage occurred during the transportation process in tomato crop. The main objective of the study was identifying the critical frequency that causes maximum and minimum losses during the process of transportation of the tomato crop. The study evaluated the losses on the basis of different parameters which were damage ratio, the equivalent bruise index (EBI) and bruise area index (BAI) where study designed a simulation prototype of five level of vibration frequency (5, 7.5, 10, 12.5 and 15 Hz), their box positions (top, middle and bottom) and their vibration duration (30, 60, 90 min) to estimate the loss that occurred during transportation process of tomato crop. The study recorded the highest value of damaged ratio, EBI and BAI at the upper box at 7.5 Hz vibration frequency for a duration of 90 min compared to other frequency levels.

Ghanghas *et al.* (2017) studied socio-demographic characteristics with awareness level and vegetables grower adoption towards post-harvest management practices. The study revealed that due to lack of knowledge and moderate awareness about post-harvest technologies, large quantities of vegetables were lost during post-harvest. The study further concluded that post-harvest management practices such as proper cleaning before marketing, grading, proper transportation were regularly adopted by the farmers' while curing and cooling of vegetables were not adopted regularly. The study suggested eco-friendly low cost technologies of post-harvest management for the enhancement of income.

Khatun and Rahman (2018) assessed a report on post-harvest losses of tomato in Bangladesh. The study revealed that at farm level around 12.5 per cent tomato was lost, of which 3.6 per cent tomato was partially damaged and around 8.9 per cent tomato was fully damaged. The study found that farmers bear great financial loss due to post-harvest losses of tomatoes in selected areas of Bangladesh. The study further suggested that developing a proper storage system, efficient disease management as well as fair price was necessary to minimize the farm level postharvest loss of tomato.

Rajesh (2018) conducted an economic analysis of postharvest losses of vegetables in which study examines the postharvest at various stages of handling in major vegetables. The study found 8.52 kg/q to 28.63 kg/q postharvest losses in major vegetables from production point to consumption point. The study also found that maximum postharvest losses in tomato followed by brinjal and minimum postharvest losses in lady finger where more intermediaries were present. The study suggested establishing vegetable producer companies in each block where the vegetable growers follow Good Agricultural Practices (GAP) to produce good quality vegetables and get fair prices for their products.

Porat *et al.* (2018) conducted a study on quantification postharvest losses of fruits and vegetables during retail and in consumers' homes. The study concluded that the retail losses were between 4 per cent and 17 per cent in which high retail losses i.e. 15-17 per cent were observed for banana, tomato and cucumber along with that moderate retail losses were 7-11 per cent observed for oranges and lower losses of 4-5 per cent were observed for potatoes, apple etc. The study also found that losses in consumers' homes are around 30 per cent of fresh vegetables and 17 per cent fresh fruits. The study suggested implementation of advanced technologies for retail and consumer use.

Dharmathilake *et al.* (2020) examined the study on post-harvest losses during supply chain of carrots, cabbage and leeks from Nuwara-Eliya to Dambulla Dedicated Economic Centers. The author identified in his study by Pilot test that Nuwara-Eliya has highest production of up-country vegetables. The study revealed that highest post-harvest losses occur in leeks (44 per cent) followed by cabbage (43 per cent) and carrots (30 per cent) due to mechanical damage. The study suggested formulation of policies that focused on post-harvest losses reduction in the supply chains of up-country vegetables.

Kyei and Matsui (2019) examine the farmers' perception toward post-harvest losses of fruits in Ashanti Region of Ghana. The study concluded that most of the fruit farmers' worried about their loss during storage and at market centers. The study further found that age, gender and farming experience were significantly related with their perceptions. The study recommended that the government should help the fruit farmers' by providing refrigeration facilities to preserve their fruit crops. He further suggested educating farmers about containers and bags suitable for storing harvested fruit crops.

Yeshiwas and Tadele (2021) reviewed a study to estimate and investigate major causes for postharvest losses of fruits and vegetables in Debre Markos, North-Western Ethiopia. The study found that 5-83 per cent of fruits and vegetables were lost during retailing, rotting, mechanical damage, poor handling, hygiene problems, inappropriate temperature conditions and storage facilities. The study further concluded that selling experience, education status and packaging material, storage and transportation methods, selling place etc. were major causes of postharvest losses in fruits and vegetables. The study suggested construction of permanent selling place for perishable produce, cooling technologies for transportation and storage, outset training, and infrastructure facilities that would reduce the postharvest losses of fruits and vegetables.

2.2 Factors affecting post-harvest losses of farmers'

Udas *et al.* (2005) carried out a study on assessment of postharvest handling systems in the Eastern hills of Nepal on four major vegetables Cauliflower, tomato, radish, cabbage. The author also studied the factors that affect the postharvest losses of vegetables crops. The study found that postharvest losses from farmers 'collection centers in cauliflower, cabbage, radish and tomatoes were 6 per cent, 9 per cent, 6 per cent, 3 per cent and at retailer's level the losses were 41 per cent, 34 per cent, 4.5 per cent, 7 per cent respectively. The study found that inappropriate packaging, transportation and grading systems were the factors that were responsible for postharvest losses of vegetables. The study further suggested that more research training can reduce the postharvest losses by adopting new technologies which would be affordable to the farmers and traders.

Ali (2012) conducted a study on factors influencing adoption of postharvest practices in vegetables. The study observed that Producers' age, education, income, farm size, irrigation availability, loan availability, information technology use, and market linkage are all major characteristics that influence the adoption of innovative farm technologies and get use for postharvest operations. The study suggested that all parties involved in the vegetable value chain should collaborate to improve the quantity and quality of vegetables delivered to customers.

Manoj (2014) investigated study on post-harvest losses of tomato crops in Jaipur district of Rajasthan. The author studied the factors that affect the post-harvest losses in tomato crop at farm level. The study revealed that around 118668 kg of tomato crops were lost at farm level and 68072.92 kg tomato lost at retail level. It was observed from the study that most of the losses occur at field level. The study found those factors such as inadequate storage, lack of labor facilities and transportation were affecting the post-harvest crops. The study recommended the use of integrated pest management practices, proper grading and proper packaging practices for the reduction of post-harvest losses in tomato crops.

Arah *et al.* (2015) examined pre-harvest and post-harvest factors affecting quality and shelf life of harvested tomatoes. The study discovered that post-harvest quality status of tomatoes depends on pre harvest practices accomplished during production such as fertilizers, appliances and cultivation selection etc. The study concluded that by understanding and managing both pre-harvest and post-harvest quality losses will reduce the post-harvest quality losses and shelf life in tomatoes. The study suggested that by using best post-harvest factors such as temperature, gases in storage, infrastructure etc. would reduce the quality losses.

Minten *et al.* (2016) conducted a study to identify the levels of food wastage at different levels of the potato food chain in Asia. The study found that during the harvest period around 5.2 per cent potatoes were wasted and around 6.4 per cent potatoes were wasted in off-season of all quantities that entered the value chain of Bangladesh. In India, quantities of potatoes wasted were equal to 3.2 per cent in harvest period and 3.3 per cent in off-season respectively. The study also found that due to the longer distances where potatoes are shipped like China, wastage level of potatoes was higher. The study further suggested that level of wastage in the potato distribution chain could be minimised by using proper cold storage facilities.

Alidu *et al.* (2016) investigate the factors that influence the postharvest losses among tomato farmers in the upper east region. The study revealed that the majority of the farmers' was male and 50 per cent of farmers fell between the age ranges 29-39 years. The study used multiple linear regression models to identify the factors that affect the post-harvest losses. The result showed that around 76 per cent of fruit was lost from harvesting to the marketing stage. The study concluded that poor road network, mode of transportation, inadequate infrastructure were the factors that affect the postharvest losses among tomato farmers. The study further recommended to improve storage facilities in the study area and to educate the farmers that could be used in processing their produce to reduce the postharvest losses among tomato farmers.

Banjaw (2017) studied the cause of losses and strategies to reduce horticultural crop losses in Ethiopia. Study found that most of the crops such as fruits and vegetables were lost during the time of harvest and post-harvest. It was revealed that less knowledge of harvesting techniques, improper storage and cooling facilities, change in climate conditions, inadequate infrastructure, improper packaging and marketing system were the major causes of post-harvest losses. The study findings suggested proper management and cultural practices, adequate infrastructure facilities, and an improved marketing system with proper handling of produce would minimize the post-harvest loss of horticulture crops. The study further recommended training programmes for post-harvest reduction.

Gautam *et al.* (2017) conducted a study on volume and value of post-harvest losses with a focus on tomatoes in Nepal. The average landholding of respondent farmers was 0.93 hectares (1 hectare = 30 *Khatta*), with vegetable agriculture accounting for nearly 36per cent of the total. The study found that on average, the farmers polled had been growing tomatoes for 15 years on a 0.2-hectare plot. The farmers' average yearly household income was $3,150, and 90 per cent of them said vegetable sales were their primary source of cash income, where they indicated tomatoes as their primary vegetable. The study found that an average farmer earned $1,888 as gross income from tomatoes alone, accounting for 60 per cent of household cash income. The majority of the traders polled thought vegetable trading was a significant aspect of their business, with tomato being the most commonly traded commodity. The study suggested improved packing, such as the use of plastic crates or wooden boxes, as well as the use of liners in rough-surface containers like bamboo baskets, would all assist to decrease quality loss.

Panghal *et al.* (2018) conducted a study with a purpose to make consumers and researchers aware about different post-harvest malpractices in fresh fruits and vegetables.

According to the findings, horticulture produce begins to deteriorate shortly after harvest, requiring appropriate storage and transportation for good quality and market value. The study found that Coloration, oiling, sweeteners, and hormone injections were all profit-driven procedures used by shops. Neither retailers nor consumers were aware of the serious health risks associated with long-term exposure to such substances. Regulatory bodies certify industries to assure quality, but certification is especially important for farmers and sellers. The study suggested that consumers should be informed of these malpractices and regulatory regulations in addition to certification and training.

Raghuvanshi *et al.* (2018) conducted a study on factors affecting post-harvest losses in Chattisgarh at farm level. The study estimated around 9.40 quintal/hectare potato was lost at farm level during post-harvest handling. The factors that affected the post-harvest at farm level were labor unavailability and improper storage facility. The study suggested that by providing financial facilities, proper equipment, and better storage facilities and for resolving labor shortage issues, the government should make some policies that reduced post-harvest losses.

Yahaya and Mardiyya (2019) reviewed post-harvest losses of fruits and vegetables. The objective of the study was to identify the factors that affect the post- harvest losses. The study found that losses that occur during post-harvest were due to lack of knowledge of proper harvesting technique, transportation, insufficient storage and distribution. Study also found that after harvest some factors such as microbial growth temperature, relative humidity, water content etc. could be controlled for freshness of fruits and vegetables. The study concluded that post-harvest losses can be reduced by implementing cultural methods and proper storage, packaging and suggested that controlled atmosphere storage was effective for fruits and vegetables.

Ahmad *et al.* (2021) conducted a study on quality and deterioration of postharvest fruits and vegetables in Pakistan. The study found that total production of fruits and vegetables was nearly 13.764 Million Tons from which 35 per cent to 40 per cent of fruits and vegetables were wasted after harvesting. The study also found that losses and deterioration of fruits and vegetables occurred during poor handling, microorganisms, mechanical damage, lack of modern technologies and time management. At last, study suggested that training and educational initiatives would help to minimize the postharvest losses.

Gathambiri *et al.* (2021) identified the postharvest practices and factors influencing postharvest losses of bulb-onion. The study found that the majority of farmers' faced 5-30 per cent bulb onion postharvest losses. The study concluded that demographic and economic factors such as land size used for onion production and education levels were influencing the postharvest losses of bulb onion. The study also found that postharvest practices such as machete and bicycles for harvesting and transportation should increase the losses of bulb onion whereas use of donkey, curing and sorting on-farm should reduce the postharvest losses. The study further recommended for training of farmers' on appropriate postharvest handling practices such as packaging, transportation, sorting, curing etc.

Gardas *et al.* (2018) evaluated critical causal factors for post-harvest losses in fruits and vegetables during supply chain by using DEMETAL approach in India. The study found that following factors such as lack of proper storage facilities, packaging facilities, infrastructure, improved handling of the products at the farm and market place etc. should be tackled diligently to reduce post-harvest losses. The study suggested that there is a need to guide various supply chain members and decision makers for reducing post-harvest losses as there is a need to improve the overall performance of fruit and vegetables supply chain food stock.

2.3 Constraint and Management techniques for managing post-harvest losses

Nasrin *et al.* (2008) conducted a study on the effect of postharvest treatment on shelf life and quality of tomato. The study revealed that tomato treatment with chlorine was then packed in polyethylene bags and kept at 20-25 degree Celsius temperature and 70-80 per cent relative humidity conditions that caused the reduction in postharvest losses. The author studies the effect of chlorine, packaging and storage conditions on quality and shelf-life of tomatoes. The study concluded that shelf-life of tomato could be extended up to 17 days as compared to non-treated and can be packed in a gunny bag for seven days only.

Nuevo and Apaga (2010) conducted a workshop on post-harvest technology that helps in reducing post-harvest losses and maintaining fruits and vegetables quality in the Philippines. The study found that most of the produce was wasted due to the improper handling, inadequate transportation, insufficient storage and use of inappropriate containers. The study also found that some technologies such as flotation method, hot water treatment for disease control, container vans, jeepneys for transportation, drip cooler for storage of vegetables etc. were used for reducing post-harvest losses. The study also discovered that Good Agricultural Practices (GAP), Hazard Analysis and Critical Point (HACCP) were used for delivering quality produce and services.

Kitinoja *et al.* (2011) assessed a study on postharvest technology in which study discussed the challenges and opportunities in advocacy, outreach and research for postharvest handling available in developing countries. The study found that appropriate developed technologies for postharvest handling relies upon environment conservation, food processing, nutrition, agricultural economics, plant biology etc. The study also found that the new technological information leads to an impact on relieving poverty in developing countries. The study further recommended that establishing a postharvest working group in each country would be useful for providing a forum for information and communication for the guidance of new technologies.

Atanda *et al.* (2011) in his study has stated the problems of post-harvest food losses in perishable crops. The study revealed from this study that initial quality of crop, temperature or storage atmosphere, genetic or environmental factors and mechanical injuries were such problems that caused post-harvest losses in perishable crops. The study concluded that by using appropriate agricultural techniques, these problems should be minimized. The study recommended the requirement of integrated approach and proper management of storage atmosphere could reduce the food losses in perishable crops.

Kitinoja *et al.* (2011) conducted a study to explore postharvest technology interventions that would directly address the challenges at the same time helping to reduce food and value losses. The study discovered that inadequate temperature control and low quality packaging were the primary causes of losses and quality issues. During field trials, the focus was on basic technology that could reduce temperature or increase package quality. The study suggested fieldwork to identify the types and sources of postharvest losses, as well as preliminary field experiments on potential solutions, led to the discovery of new research requirements for fruit and vegetable crops.

Kramchote *et al.* (2012) conducted a study to determine the effect of low temperature storage to maintain postharvest quality of cabbage in the supply chain. The study revealed that cabbage can be stored at 4 degree Celsius for 18 days followed by 10 degree Celsius for 12 days; at ambient conditions i.e. 28 degree Celsius where it deteriorates rapidly and would last for only 4 days. The study further concluded that at 4 to 10 degree Celsius the yellowing of leaf delayed, weight loss, respiration rate, ethylene production were also reduced and firmness of head also maintained at low temperature.

Garikai (2014) investigated the principal vegetables farmed by smallholder farmers as well as their knowledge, training, postharvest management procedures, and quantity lost in Umbumbulu, South Africa. According to the survey, only a tiny percentage of farmers cultivate their vegetables primarily for consumption, while the majority grows them primarily for sale. On the other hand Farmers with more experience had fewer postharvest losses than those with less experience. The study revealed farmers had received training more than a year before the survey was conducted. The result shows that root vegetables had smaller postharvest losses than leafy and fruit crops. The study suggested that agricultural extension and training services have been proven to have an impact in reducing postharvest losses.

Duong (2014) conducted a training course on post-harvest technology vegetables. The main aim of this training course was to provide knowledge on post-harvest technology who were involved directly in the vegetable value chain to reduce post-harvest losses and improve quality of vegetables with production techniques value addition and management which will increase income of vegetables growers. The study concluded that knowledge and training programmes that were given to participants will increase the productivity and good quality of vegetables engaged in the value chain with higher benefits. The study suggested to previous participants to broaden their knowledge on new technological issues and discusses problems that arise during application of post- harvest technology.

Nura (2015) has stated post-harvest management of fruits and vegetables. The study concluded due to the perishable nature of fruits and vegetables both quantity and quality were affected after harvest. The study found that post-harvest losses occur due to lack of awareness, inadequate infrastructure facilities and lack of functioning equipment. The study recommended pre and post-harvest management practices such as use of improved variety, permitted chemical, proper packaging, adequate infrastructure facilities and storage atmosphere management were some control measures used in reducing post-harvest losses of fruits and vegetables.

Wakholi *et al.* (2015) reviewed the postharvest handling technologies commonly used with fruits and vegetables in East Africa. The study revealed that there are maximum small-scale producers of fruits and vegetables. The study discovered that many of these small-scale farmers handled their limited quantities of crops using simple and inexpensive procedures and the following factors that could be rectified to reduced post-harvest losses are weak policies, inadequate infrastructure, and poor market tactics, lack of basic knowledge among stakeholders on how to develop, implement, use, and sustain the recommended handling technologies. The study suggested bridging the knowledge gap be given top priority, since this will help all stakeholders better address and reduce postharvest losses.

Arah *et al.* (2015) identified the post-harvest challenges that make tomato production unprofitable. The study stated that both on-farm and off-farm post-harvest challenges were affecting the tomatoes production where on-farm losses were caused by improper harvesting stage, packaging material and harvesting container and off-farm losses were caused by inappropriate transportation system, lack of reliable market information etc. The study suggested that using low cost intermediate technology intervention would help in post-harvest reduction in tomatoes.

Parmar *et al.* (2016) conducted a study on post-harvest handling practices in the sweet potato value chain of Southern Ethiopia. The objective of study was to assess the degree of post- harvest food losses at different levels. The study found that some factors such as physical, biological demand and supply mismatch during harvest season were the main cause for food losses. The study concluded that during harvest and handling at farm level and shelf-life issue at distribution level leads to economic losses up to 33-75 per cent. The study suggested that multi-stakeholder cooperation is needed to mitigate post- harvest losses.

Faqeerzada *et al.* (2018) reviewed a study on postharvest technologies for fruits and vegetables in South Asia countries. The study revealed that to reduce the postharvest losses, it was necessary to use low cost technology such as zero or low energy cool storage, field packing system, containers for transportation and increasing the farmers income as small-scale farmers were unable to use high level or expensive technologies like developed nations.

The study concluded that the adoption of low cost technologies in the South Asian region would support the small scale farmers by reducing the postharvest losses in fruits and vegetables that increase their income and improving the lives of individuals, nations and the South Asian region as a whole.

Wetherill *et al.* (2018) describes opportunities and challenges to produce recovery of edible fresh food produce to build healthy food assets banking in the United States. The study discovered lack of cold storage and transportation capacity as major challenges. The study suggested enhancing food banking capacity for F and V recovery offers another potential solution to reduce nutrition disparities among food insecure populations as well as enhanced cross-sector collaboration and planning efforts are needed to ensure FBs receive donations that can be redistributed in a timely manner. The study showed that in order to optimally recover and redistribute fresh food, cross-sector coordination and planning efforts across the agricultural, health, and charitable feeding sectors are required.

Hasan *et al.* (2019) conducted a study on modern drying techniques in fruits and vegetables to overcome postharvest losses. The study primarily examined crop-specific activities, as well as their effects on quality, efficiency, cost-effectiveness, and nutrient retention. The study concluded that while developing crop -specific future drying technologies, various essential criteria such as product quality, drying time reduction, energy efficiency, and overall cost effectiveness should be considered.

Maiti *et al.* (2018) assessed a study on post-harvest management of agricultural produce. The objective of study was to examine the post-harvest losses in the regulated market of Jabalpur. The study found that 20-40 per cent post-harvest losses in fruits and vegetables resulted in about 10-15 per cent fruits and vegetables losses due to lower market value and consumer acceptability. The study suggested that post-harvest losses could be reduced by adapting some advanced techniques.

Degebasa (2020) reviewed a study on prospects and challenges of postharvest losses of potato in Ethiopia. The aim of study was to evaluate improved seed, ware potato storage, local farmers' practices such as extending harvesting, storing under bed and in a pit. The study revealed that local farmer practices were not effective for long- term storage of potato due to rapid sprouting. The study concluded that improved seed and ware potato storage were effective where temperature and relative humidity were suitable for potato.

Santos *et al.* (2020) conducted a study to determine the extent of post-harvest losses of fruits and vegetables in Salvador's Central Supply (CEASA).The study also focused on the determinants and potential solutions to minimize the problem. The study discovered that a weekly loss in the study area was 9.5 Tonnes in bananas followed by papayas, tomatoes, peppers, and lettuce. The study found that excessive volume in purchases, storage without refrigeration, and reckless handling by consumers and vendors were the leading causes of loss. The study suggested infrastructure improvements as well as advances in hygienic care, administration, and post-harvest storage of fruits and vegetables.

Tolulope and Adeladun (2021) investigated study on effect and precaution or prevention of post-harvest losses in fruits and vegetables. The study concluded that improper storage condition, handling and improper maturity during harvest were the main cause of postharvest losses. The study also found that due to immature harvest, quality of fresh produce is affected which leads to damaging tissues of fruits and fruits and vegetables. The study suggested to harvest on time for quality and safety of the harvested fruits and vegetables in order to improve the shelf-life which reduced the post-harvest losses of fruits and vegetables.

Kahramanoglu *et al.* (2021) reviewed a study on enhancing fruits and vegetables security during covid-19 pandemic with post-harvest handling. In this study the study focused on the impact on horticulture production and some prevention measures during covid-19 pandemic. The study found that in developed countries fruits and vegetables losses occur around 10-15 per cent and in developing countries the losses occur around 20-40 per cent after post-harvest. The study suggested implementation of modern technologies including CA (Control Atmosphere) storage, film wrapping, and proper grading from harvesting to consumption is required. Study also recommended appropriate logistic and cold chain facilities during transportation for farmers and the government.

Existing research on post-harvest losses in vegetable crops demonstrates the major influence of inefficient handling, transportation, and storage procedures on produce, with losses ranging from 20-40%. Improper packing, poor infrastructure, and a lack of training all contribute to the losses. Modern technology, specialized transportation techniques, and effective post-harvest procedures emerge as the most important solutions. In Himachal Pradesh, an area recognized for its farming practices, acknowledging and dealing with these concerns is essential. The findings highlight the need for specific governmental measures to reduce post-harvest losses, increase agricultural production, and protect farmers' livelihoods. In Himachal Pradesh, where agriculture is essential for the economy and livelihoods of the native populations, understanding post-harvest losses in vegetable crops is even more important. Himachal Pradesh's distinct geographical and meteorological characteristics present specific problems that might have a different influence on post-harvest activities than in other regions. Understanding these complexities is essential for developing region-specific solutions that reduce losses and improve revenue for local farmers. Furthermore, as Himachal Pradesh encourages horticulture and vegetable growth as part of its agricultural diversification policy, reducing post-harvest losses is critical to maintaining food security, economic sustainability, and overall agricultural resilience in the state.

The preceding literature review revealed a notable gap in comprehensively addressing the prevailing circumstances regarding post-harvest losses concerning tomatoes, cabbage, and green peas. Moreover, while some attention was given to the constraints faced by farmers in mitigating these losses and the socio-economic factors influencing them, a comprehensive analysis was lacking. Hence, the present study endeavors to illuminate the current state of post-harvest losses and the socio-economic determinants impacting them. Additionally, it aims to identify key constraints and propose measures to alleviate post-harvest losses. Furthermore, this study delves into the management practices adopted by farmers, an aspect that has received limited scholarly attention.

Chapter-3

MATERIALS AND METHODS

An approach for systematically dealing with the research challenge is known as research methodology. A research technique is a method for solving a research problem in a methodical manner (Kothari, 2005). It may be described as the study of scientific research methodology. Techniques which deal with the data and techniques used for analysis are an essential component of research studies. Information that is both quantitative and qualitative is mostly referred to as material. The chapter describes the research design, sampling methodology, and sample size in detail. This chapter describes the data gathering methodologies utilized in the study, as well as the methods used to analyze the data. The study's methodology has been examined under the following subsections:

3.1 Location of the Study Area
3.2 Selection of Research Area
3.3 Sampling Design
3.4 Data Collection
3.5 Analytical Framework

3.1 Location of the Study Area

Himachal Pradesh is located in the western Himalayas, between latitudes 30°22′N and 33°12′N and longitudes 75°47′E and 79°04′E. the state spans 55,673 square kilometers (21,495 sq. m). The State of Himachal Pradesh is divided into valleys that are covered by numerous year-round rivers. The state's economy mostly depends on hydropower, tourism, horticulture, and agriculture. The state territory divided into three zones i.e. Outer Himalayas, inner Himalayas and greater Himalayas. In the southern low tracts of the state, the climate is hot and humid tropical; in the northern and eastern high mountain ranges, it is warm and temperate, chilly and temperate, alpine and glacial. With an elevation range of less than 650 to more than 2200 m amsl, the entire State of Himachal Pradesh is divided into 4 agro-climatic zones i.e. low hills sub-tropical, mid-hills sub-humid, high hills temperate wet and high hills temperate dry. Almost all the agricultural, fruit and Vegetable crops are grown in different agro-climatic zones of Himachal Pradesh.

Table 3.1 Agro-climatic zones of Himachal Pradesh

Zone	Specified Name	Elevation Range (in amsl)	Areas
Zone-I	Low hills sub-tropical	<650	Una, Bilaspur, Hamirpur, Kangra, Solan , Chamba districts and parts of Sirmour districts
Zone-II	Mid-hills sub-tropical	651-1800	Palmpur, Rampur tehsil of District Shimla, Kangra tehsil of district Kangra, parts of Mandi, Kullu, Chamba, Solan districts and Sirmour district
Zone-III	High hills temperate wet	1801-2200	Shimla (except tehsil Rampur), Solan, Chanba, Mandi, Kangra, Sirmaour districts and parts of Kullu district
Zone-IV	High hills temperate dry	>2200	Kinnaur, Lahul&Spiti districts and parts of Chamba district

Source: Annual report 2020-2021, DoA

3.1.1 Land Utilization Pattern of Himachal Pradesh (2021-22)

Agriculture is an important economic sector of Himachal Pradesh, relying heavily on land resources. Land availability, soil type, and land-use patterns all have a substantial influence on the agricultural economy. The diversification process has turned toward high-value crops, influencing land use and cropping patterns. The fast growth of human and animal populations has driven this transition, resulting in changes in cropping patterns and land use intensity. According to an economic analysis, the country's total geographical area is 5567 lakh hectares, of which 81.70 per cent is reported and 11.90 per cent is net planted (Bains and Atlas, 2022).

Table 3.2 Land Utilization Pattern of Himachal Pradesh (2021-22)

Sr. No.	Particulars	Area (in ha)
1	Total Geographical area	4577984
2	Forest land	1123800
3	Land under misc. tree crops not included in area sown	67643
4	Permanent pastures & other grazing lands	1502648
5	Cultivable waste lands	124853
6	Land put to non-agricultural uses	365258
7	Barren and unculturable land	765774
8	Current fallows	78844
9	Other fallows lands	23270
10	Net area sown	525894
11	Area sown more than once	372689
12	Total cropped area	898583
13	Cropping intensity	170.87%
14	Net irrigated area	120186

Source: HP DoA Agriculture Census, 2022-2023

Table 3.2 depicts the Himachal Pradesh land usage pattern for 2021-2022. Forest land accounts for approximately 11, 23,800 hectares of Himachal Pradesh's total land area of 4,577,984 hectares. Some hectares of land are unsuited for agriculture, including non-agricultural regions (3, 65,258 ha) and barren and uncultivated land (7, 65,774 ha). The state has several types of uncultivated terrain, including cultivable waste fields (1, 24,853 ha), permanent pastures, and other grazing grounds (15, 02,648 ha). It also includes fallow land, which is divided into current (78,844 ha) and other fallows (23,270 ha). The entire net irrigated area is 1, 20,186 hectares.

3.1.2 Size-based operational holdings in Himachal Pradesh

Farmers in Himachal Pradesh are categorized into five major divisions depending on the size of their land: marginal (less than 1.0 ha), small (1.0 to 2.0 ha), semi-medium (2.0 to 4.0 ha), medium (4.0 to 10.0 ha), and large (more than 10 ha).

Table 3.3 Operational holdings by size in Himachal Pradesh

Size of Holdings (ha)	Category (Farmers)	Number of Holdings (Lakhs)	Area (Lakh ha)	Average Size of Holding (ha)
Below 1.0	Marginal	7.12 (71.41%)	2.86 (30.30%)	0.40
1.0 - 2.0	Small	1.74 (17.45%)	2.42 (25.63%)	1.39
2.0 - 4.0	Semi-Medium	0.82 (8.23%)	2.23 (23.62%)	2.72
4.0 - 10.0	Medium	0.26 (2.61%)	1.46 (15.47%)	5.62
10.0 - Above	Large	0.03 (0.30%)	0.47 (4.98%)	15.67
	Total	9.97 (100%)	9.44 (100%)	0.95

Source: DoA Economic Survey, 2022-23

The acreage, proportion, and size of each land holding pattern and area operated are shown in Table 3.3. The average land holding size in the State is 0.95 hectares, and there are 9.97 lakh operating holdings spread across 9.44 lakh hectares, most of the farmer of Himachal Pradesh are small and marginal farmers. The distribution of farmers' holdings is as follows: marginal farmers make up 71.42 per cent of all farmers, small producers 17.45 percent, semi-medium producers 8.25 per cent, medium producers 2.61 per cent, and large farmers 0.30 per cent.

3.2 Selection of Research Area

3.2.1 Selection of Districts for Study

The first step involved selecting the districts based on the maximum area under cultivation for vegetables. It was found that the districts of Mandi, Shimla, and Solan contain the most of vegetables concentration areas. Consequently, these districts served as the primary foundation for the sample selection process. In terms of percentage share of the entire vegetable area during the period 2012–2020, Shimla district has the highest (17.15%), followed by Mandi and Solan districts (13.62% and 12.86%), respectively. More than 40% of the State's total vegetable-growing acreage was included in these three areas. Therefore, Shimla, Mandi, and Solan districts were purposefully chosen for the current study based on the higher proportionate share under the chosen vegetable crops (Paul, 2020). Also, districts were chosen in accordance with the larger area and production share of Tomato, Peas and Cabbage in 2021–2022 (HP DoA Annual Report, 2021-2022)).

Table 3.4 District-wise area and production of selected vegetable crops

Crop	Solan		Mandi		Shimla	
	Area (ha)	Production (MT)	Area (ha)	Production (MT)	Area (ha)	Production (MT)
Tomato	5183	256559	1007	25079	932	48297
Peas	1643	16430	3667	62339	7030	81807
Cabbage	103	2060	1074	28294	1280	49920

Source: HP DoA, Annual Report, 2020-21

3.2.2 Selection of Vegetable Crops for Study

The present research starts with a specific purpose in consideration as Himachal Pradesh has grown to become a prominent state in the country for vegetable production. As per the recent report publish by Statistical Abstract of Himachal Pradesh (2021-2022), the total area under vegetable crops is 86,821 hectares and total production of vegetable crops is 18,03,836 tons. Therefore, it's important to examine the patterns of area, production, yield, and losses for specific vegetable crops. Three important vegetable crops namely Tomato, Peas and Cabbage grown in State were selected for inclusion in the study area. Out of all the vegetable crops in the state, Tomatoes (13,795 ha & 5, 77,005 MT) followed by Peas (25,997 ha & 3, 28,804 MT), and cabbage (4,561 ha & 1, 46,659 MT) were chosen for research study due to their significantly larger area and higher production.

Table 3.5 Selection of vegetable crops

District	Seasonal Vegetables																	
	Peas (Green)		Tomato		Beans		Onion		Garlic		Cabbage		Cauliflower		Radish		Turnip	
	Area	Prod.	Area	Prod.	Area	Prod.	Area	Prod.	Area	Prod.	Area	Prod.	Area	Prod.	Area	Prod.	Area	Prod.
Bilaspur	196	3332	877	33326	107	1819	297	6749	159	3021	60	2520	180	4610	101	2828	22	616
Chamba	1668	23252	383.48	19557	312	3432	115.6	5837	108.88	1524	188.7	4943	50.19	602	127	2842	18.11	333
Hamirpur	174.5	2355	94	5166	89.5	1061	360	8157	358	5871	41	935	589	14685	138	2106	65	1885
Kangra	683.2	9093.3	351	8879	331.5	3981.5	1056	25519	418	5469	423.8	6726	617.4	10662	584.5	14517	141.3	4793
Kinnaur	2600	28994	76	3467	365	3342	15	297	13	167	128	3846	78	1484	33	668	20	758
Kullu	2800	42144	920	37260	85	850	80	1248	1020	20400	1000	34410	740	15850	110	2566	60	1358
Lahaul Spiti	3648	37402	3.5	75	19	132	0	0	0	0	48	1423	533	20780	22	426	9	118
Mandi	3667	62339	1007	25079	660	11000	498	10458	492	12054	1074	28294	842	20766	440	9925	90	2002
Shimla	7030	81807	932	48297	925	15155	103	2060	212	2321	1280	49920	1495	36615	201	2071	33	363
Sirmour	1845	21312	3833	134937	507	5947	367	4398	3958	60637	292	11082	281	4464	96	1512	47	1196
Solan	1643	16430	5183	256559	835	16850	282	5922	442	4420	103	2060	175	3500	145	3190	28	616
Una	42	344	135	4403	16	166	238	4182	13	187	23	500	58	1091	89	2088	73	1625
Total	**25997**	**328804**	**13795**	**577005**	**4252**	**63736**	**3411**	**74827**	**7193.9**	**116071**	**4661**	**146659**	**5638.6**	**135109**	**2087**	**44739**	**606.4**	**15663**

(Area in ha and Production in M.T.) Source: HP DoA, Annual Report, 2020-21

Table 3.4 Contd…….

District	Seasonal Vegetables															
	Carrot		Bhindi		Cucurbits		Capsicum		Chillies		Brinjal		Turmeric		Other Vegetables	
	Area	Prod.	Area	Prod.	Area	Prod.	Area	Prod.	Area	Prod.	Area	Prod.	Area	Prod.	Area	Prod.
Bilaspur	7	196	365	6570	226	7602	74	813	45	720	56	1792	260	2860	459	14332
Chamba	33.7	669	131.6	1185	60.91	1584	20.77	560	20.8	218	36.5	1103	8.42	152	177.89	4129
Hamirpur	2.5	34	698	14658	389	14087	21.5	306.2	68	369	47	663	253	8294	715	12436
Kangra	17.5	306	1394	20783	885.5	17674	71.2	994.5	223.5	2203	258.7	5246	274	5103	834	12223
Kinnaur	11	223	16	192	33	1162	27	544	18	185	15	389	0	0	295	2967
Kullu	15	192	95	1188	130	1950	85	1063	100	797	60	1083	8	128	0	0
Lahaul Spiti	9	99	0	0	8	210	4	18	0	0	0	0	0	0	0	0
Mandi	63	1386	420	7140	332	8300	267	4806	80	960	273	5511	70	1960	823.5	18498
Shimla	28	360	47	376	264	3959	326	4217	15	244	69	1339	4	40	337	5544
Sirmour	55	1163	207	2234	114	3718	473	7560	424	6293	80	1940	127	1977	159	2705
Solan	0	0	155	1550	376	9400	1460	27740	115	1150	82	1230	191	2292	756	9072
Una	5	150	386	5074	109	3715	19	238	35	339	35	622	47	943	1153	18895
Total	**247**	**4778**	**3915**	**60950**	**2927**	**73361**	**2848**	**48859.7**	**1144.3**	**13478**	**1012.2**	**20918**	**1242.42**	**23749**	**5709.39**	**100801**

(Area in ha and Production in M.T.)

Source: HP DoA, Annual Report, 2020-21

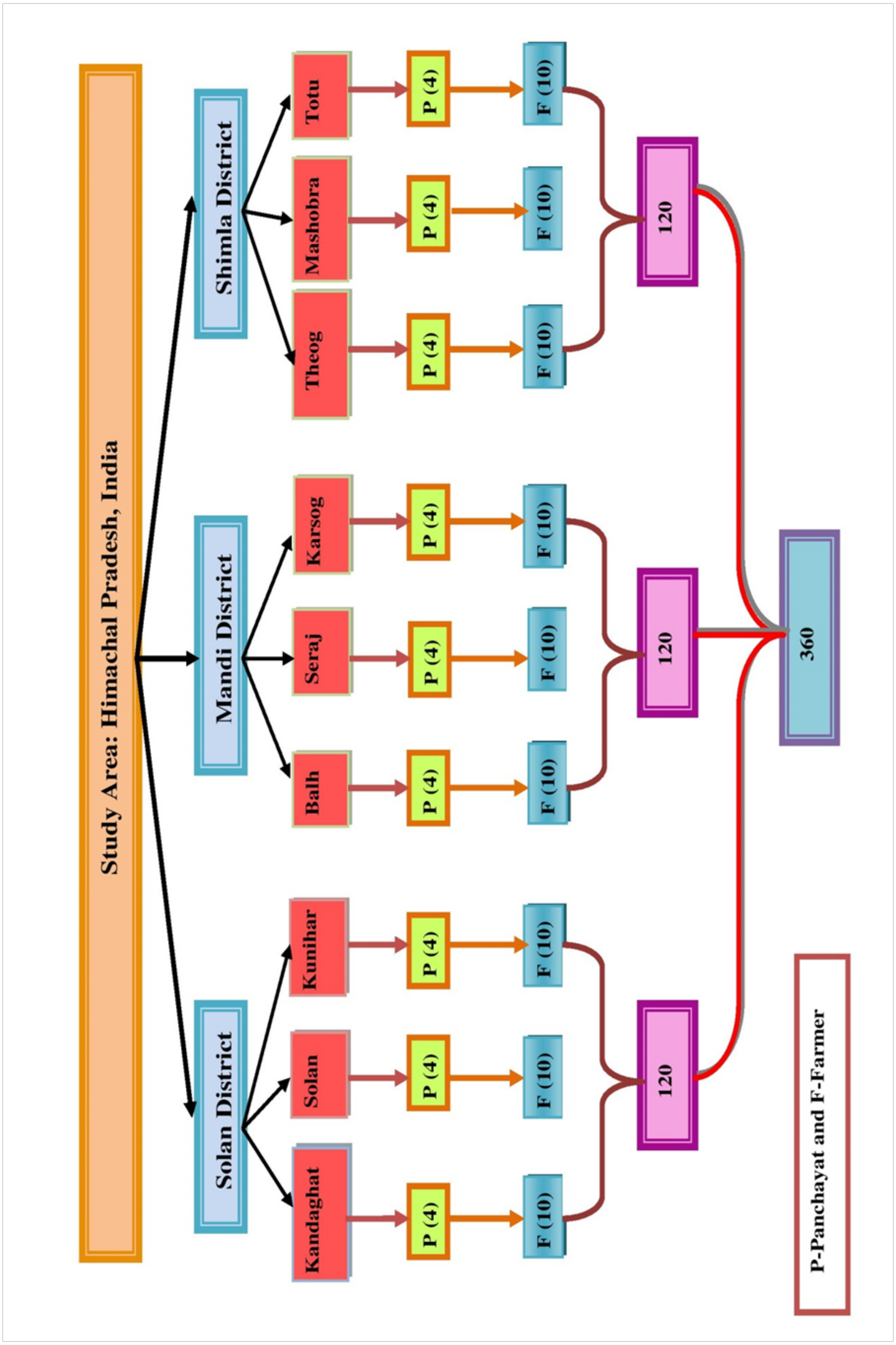

Figure 3.1: Sampling Framework

3.3 Sampling Procedure

3.3.1 Sampling Design

To infer the features of the whole population, a selection of individuals is selected from a larger group through the process of sampling, which is a critical component of qualitative research. Studying a subset of a population allows for the collection of information about the entire population (Kabir, 2016).An efficient method of combining procedural economy with research purpose relevance is known as a sampling design. It involves setting up parameters for data collecting and analysis (Kothari, 2005). The overall strategy defines the strategies the researcher will use to obtain accurate, unbiased, and evaluative data. A quantitative, descriptive research approach was chosen for this study to provide a full explanation of vegetable postharvest losses (Garikai, 2014). The multistage sampling approach was utilized due to the large population size, necessitating a larger sample size for equivalent accuracy (Asrat and Simane, 2018). A multistage random sampling approach was used to select the final sample for study area. Himachal Pradesh has divided into four agro-climatic zones and twelve districts. The households sampled were selected from three districts in the State i.e. Solan, Mandi, and Shimla. At every stage of the sampling process, the samples were chosen at random using lottery.

3.3.1 Selection of Blocks

A complete list of blocks in the selected district was prepared. Then, in the first sample stage, three blocks from each specified district were chosen with the guidance of an agriculture officer at the block level (ADO) based on the maximum cultivated area under the selected vegetable crops. In the Mandi district, there are fifteen (14) blocks. Three blocks randomly picked were made from a total of 14 Mandi blocks using a random number generator. The Shimla district consists of thirteen (13) blocks, three of which were chosen by the process of random number generation. Similarly Solan district consist of five blocks, out of which three blocks chosen. Table 3.6 below shows list of selected blocks.

Table 3.6 Selection of blocks from each selected districts

Sr. No.	District	No. of Blocks	Total Number of Blocks under selected District	Name of selected Block
1.	Solan	**5**	Solan, Kandaghat, Dharmpur, Nalagarh and Kunihar.	Solan, Kandaghat and Kunihar
2.	Mandi	**14**	Chauntra, Balh, Karsog, Churag, Dharampur, Drang, Gopalpur, Sundernagar, Dhanutu, Nihri, Mandi Sadar, Gohar, Seraj and BNali-Chowki.	Balh, Seraj and Karsog
3.	Shimla	**13**	Mashobra, Basantpur, Chopal, Chhohara, Rohru, Jubbal, Kotkhai, Theog, Rampur, Nankhari, Narkanda, Kupvi and Totu.	Theog, Mashobra and Totu

Source: Govt. of Himachal Pradesh, 2021-2022

3.3.2 Selection of Panchayats

In the second sample stage, a comprehensive list of all the Gram Panchayats in the selected blocks was prepared from Directorate of Panchayti Raj, Government of Himachal Pradesh. From the given list, four gram panchayats were chosen by random sampling technique from each selected block i.e. lottery method. The lottery method is a random selection process that aims to obtain a random and impartial sample of panchayats for analysis. It follows the concepts of randomness, fairness, and equal opportunity for each element in the population. The procedure involves identifying and labeling each panchayat, folding and mixing the slips, blindfolding an impartial expert, and choosing panchayats solely on chance. The slips are made in identical sizes, shapes, and colors to ensure no bias. The expert then draws slips at random from the mixed pool, adding an extra degree of randomization. The lottery method ensures an equal chance of selection for every panchayat in the chosen blocks.

3.3.3 Selection of Sample Respondents

The main objective of survey is to effectively express community characteristics by utilizing data to generalize conclusions from a selected sample to a wider group while taking into consideration random variation restrictions (Alhaji, 2010). The estimation of sample sizes is the process of determining the proper number of observations in a sample, which is critical for research or inquiry that seeks to derive demographic inferences (Singh and Masuku, 2014).


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Figure 3.2: Data Collection

The sample size was calculated using the Krejcie and Morgan (1970) methodology. The Krejcie and Morgan (1970) formula is a widely used and cited method for determining sample size using a limited population. The optimal size for the current investigation was 360, as calculated by Krejcie and Morgan's (1970) formula. The sample size of 360 was then distributed equally across the three designated districts Figure below.

Krejcie and Morgan (1970) Formula:

$$s = x^2NP(1-P) \div d^2(N-1) + x^2\,P(1-P)$$

Where,

s = required sample size

x = table value of chi-square for one degree of freedom at the desired confidence level (3.841)

N = population size

P = population proportion (40%)

d = degree of accuracy expressed as a proportion (0.05)

3.4 Data Collection

The data used in this study was obtained from a combination of primary and secondary sources. During the agricultural year 2021-2022, data was collected. Following an extensive evaluation of the literature and consultation with an expert in the field, a structural schedule for interviews was developed. To achieve the study's objectives, both primary and secondary data were collected.

a) Primary Data

The original and first-hand data, which are known to possess unique characteristics, are considered primary data. Primary data was collected through the use of the well-structured and thoroughly tested questionnaire along with the personal interview approach. Primary data for the study were acquired from selected farmers directly pertaining to agricultural year 2021-2022. A questionnaire is a widely used tool for gathering data in social science research, aiming to provide reliable and legitimate information (Taherdoost, 2016).

Survey instrument

The five sections of the questionnaire were designated as Section A, Section B, Section C, Section D, and Section E, in that order.

Section A: Socio- Demographic Characteristics

This section contained information on the socioeconomic backgrounds of the survey respondents. Gender, age of the sampled respondents, respondent education level, income status of the respondents, farming experience, famers family size and land holding capacity of the sampled respondents. All the variables in this section were categorical in nature.

Section B: Existing Status of Post-harvest Losses during marketing of selected vegetable crops

Firstly, the secondary sources of information (Directorate of Agriculture, Shimla, HP) included information about the region, how it was used, and the production and efficiency of the main crops. Then, a series of quantitative questions prepared aimed at collecting data regarding the selected vegetable crop production (in quintals) and post-harvest losses happened in different stage of marketing (in %). Farmers' responses for post-harvest were taken as a range since, as was noted during the questionnaire's pre-testing phase, they were providing estimations rather than a precise proportion of post-harvest losses, such as 5%–10% and 15%–25%.

Section C: Factor affecting post-harvest losses and management practiced adopted by the farmers during marketing of selected vegetable crop

In this section of the questionnaire, questions pertaining to the factors that were affecting post-harvest losses in the research region. Dichotomous question that were related to the factor of post-harvest losses were included:

- Age of the respondents
- Education qualification of the respondents
- Family size of the respondents
- Land holding capacity of the respondents
- Farming experience of the respondents
- Distance to the market

- Time of Harvest
- Post-harvest handling training
- Type of packaging
- Time of sale
- Storage facility
- Labour used for harvesting
- Access to market information
- Method of harvesting

Furthermore, a series of Likert scale questions were devised to assess farmers' implementation of management strategies to decrease post-harvest losses in the selected vegetable crops. The question employed a five-point Likert scale to measure the responses of participants to several criteria. This study employed a 5-point Likert scale with a range of 1 to 5, where SA: Strongly Agree, A: Agree, N: Neutral, DA: Disagree and SD: Strongly Disagree. Respondents were asked to select the option that most accurately represented whether they agreed or disagreed with the specified procedure.

Section-D: Constraints and suggestion for management intervention for managing post-harvest loss

In this part, questionnaire included the constraints faced by the farmers during the process of marketing of selected vegetable crops. The constraints related to the production, marketing, education, financial, technical and infrastructure faced by the farmers has been discussed in the present study. Likert scale was used to rank the constraints faced by the farmers for managing the post-harvest losses in the tomato crops (I- Extremely high, II- High, III- Moderate, IV- Low and V-Extremely low).

Furthermore, the last question of the questionnaire aimed to identify the most important suggestions for reducing post-harvest losses in selected vegetable crops. Farmers were asked to rank these suggestions from 1 to 5, with 1 being strongly agree and 5 being strongly disagree. The ranking technique was used to determine the most effective strategies for reducing losses during marketing.

b) Secondary Data

The data classified as secondary are those that have previously been gathered and subjected to the statistical analysis by someone else. The necessary information related to present study were gathered from various published sources such as bulletins, journals, specific websites, books, university reports, research gate, Krishikosh, Shodhganga etc., as well as other boards, governments departments like horticulture, agriculture, directorate of economics and statistics.

3.5 Analytical Framework

To accomplish the objectives of the present research simple mathematical and statistical tools such as mean, percentage and frequency distribution and some other tools were used for the analysis of collected data. Software such as MS Excel 2016, SPSS-22 and STATA 18 were used to perform the statistical and econometric analysis. Basic mathematical techniques and statistical tools were used in the research. Basic mathematical techniques, including measures such as the mean, percentage, and frequency distribution were used to know the existing status of post-harvest losses in selected vegetable crops. The statistical tools that were used include standard deviation, compound growth analysis, ordered probit regression model, principal component analysis and multiple response analysis and Kendall W analysis.

3.5.1 Mathematical Tools

a) Tabular Analysis

A researcher has to organize a large amount of data into a clear, logical sequence once it has been assembled. This process is known as tabulation (Kothari, 2005). To determine the various socioeconomic characteristics such as age, gender, family structure, education status, occupation status, income status, farming experience and land holding capacity of the sampled farmers, tabular analysis was used.

b) Percentage Method

The term "percentage" refers to a specific form of ratio used to compare two or more sets of data (Gupta, 2017).

The formula used for percentage method is:

$$\boldsymbol{P = \frac{X}{Y} \times 100}$$

Where,

P= Percentage

X= Number of respondents falling in specific category to be measured.

Y= Total number of respondents.

3.5.2 Statistical Methods

a) Arithmetic Mean

The qualitative assertions have been given numerical values in order to determine the arithmetic mean. It is the most widely used measure of central tendency and is calculated by dividing the total number of items in a series by the sum of the values of the individual items (Kothari, 2005).

The formula used for Arithmetic Mean is:

$$\bar{X} = \frac{\sum X_i}{n}$$

Where,

$\bar{X}$ = Mean

$\sum$= Symbol of summation

X_i= Value of the ith X, 1, 2,…, n

n = Total number of items

b) Standard Deviation

The standard deviation concept was introduced in 1823 by Karl Pearson. It is defined as the square-root of the average of squares of deviation generated from the arithmetic average of the individual values in a series (Kothari, 2005). The absolute dispersion is measured by the standard deviation, the larger the standard deviation, the larger the magnitude of the values' divergence from the mean. A small standard deviation indicates both high levels of series homogeneity and uniformity of the observation; a large standard deviation indicates the exact opposite.

The formula used for standard deviation is:

$$\sigma = \sqrt{\sum X^2} / N$$

Where,

$X = (x - \bar{x})$

N= Number of observations

c) Compound Annual Growth Rate

The compound growth rate for different variables such as area, production and productivity were calculated by fitting the exponential function for the period of 2012-2022 of selected district of Himachal Pradesh. To fit the power function, the standard least squares method was applied (Sethi *et al.,* 2022). The logarithmic transformation was used to change it into a log linear function under:

$$\mathbf{Y = ae^{bt}}$$

Or

$$\mathbf{\log Y = \log a + bt}$$

Where,

Y = Dependent variable (area, production and productivity etc.)

T = Independent Variable (time in a year).

Compound growth rate (CGR) was calculated by using the following formula:

$$CGR = b \times 100$$

For significance testing t value was calculated by using the formula:

$$t = \frac{CGR}{SE(CGR)}$$

d) Trend Analysis

Trend analysis was done for the variables that could be obtained over a ten-year period, such as the area used for vegetable cultivation and the production of particular vegetable crops. A linear relationship is shown by a trend line.

e) Garrett Ranking Method

The Garret ranking method offers a significant advantage over basic frequency distribution by organizing constraints based on respondents' perceived severity (Zalkuwi *et al.,* 2015).

The Garrett ranking approach was used to examine several post-harvest situations (rotting, pest and disease during storage, under- or over-mature fruit, etc.) that result in the most harm in the study area. The Garrett technique has an advantage over a basic frequency distribution in that it arranges the conditions that result in the greatest post-harvest losses according to their severity as perceived by farmers. Garret's ranking approach was used to identify and prioritize challenges faced by farmers for reduction of post-harvest losses in selected vegetable crops. Farmers were asked to rank these challenges in a designated region. A schedule was created to examine constraints, which were categorized into production related, marketing related, finance related, technical and infrastructural related. The reactions of the sampled farmers were documented. The rankings assigned to a constraint were converted into percentile positions using the following formula (Raghav and Sen, 2014).

The following formula was used to get the percent position for each rank:

$$\text{Per cent position} = \frac{100\,(Rij - 0.5)}{Nj}$$

Where,

R_{ij} = Rank given to i^{th} position by the j^{th} individual

N_j = Numbers of problems ranked by j^{th} individual

The per cent position was converted into scores by referring to the Garrett ranking conversion table (Garrett and Woodswordh, 1969). Then, each respondent's total score for each factor was divided by the sum of all respondents' scores for that factor. These mean scores were ranked, arranged in descending order, and the most crucial elements were identified.

Table 3.7 Garrett ranking conversion table

Percent Position	Garratt Score
10	75
30	60
50	50
70	40
90	24

Source: Garrett and Woodswordh, 1969

Factor affecting post-harvest losses

Ordered probit regression was used to investigate the variables causing post-harvest losses among farmers. The following is a discussion of the chosen explanatory variables and model.

f) Ordered Probit Regression Analysis

A technique that is frequently used for evaluating models of ordered categories is the ordered probit model. Like the binomial probit model, the ordered probit model is based on a latent regression **(**Ade and Bosede, 2016).The extended linear models framework includes the ordinal regression model (Dooga *et al.,* 2021).

The factors affecting vegetable postharvest losses were identified using the Ordered Probit Model. The percentage of lost tomatoes, cabbage, and green peas, sorted into three ordered groups, served as the dependent variables in this study. Less than 5%, 5 to 25%, and more than 25% are the groups.

The ordered probit model was employed in this study to determine the variables affecting farmers' postharvest losses. Drawing from the literature study, the model's estimation is as follows:

Quantity of Tomato, Cabbage and Green Pea lost = f (age, education, method of harvesting, family size, land holding capacity, farming experience, distance to the market, time of harvest, post-harvest handling training, type of packaging, time of sale, storage facility, labour used for harvesting and access to the market information).

This latent variable, q i *, represents the corresponding category for amount lost, which is unavailable for observation. The following latent equation, which is expressed as follows, describes how qi * changes depending on individual traits:

$$q_i^* = X_i + \varepsilon_i \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$$

Where:

- The latent variable **qi** *measures the difference in utility derived by individual i from either losing between less than 5%, 5 to 25%, and more than 25%.
- (**i** = 1, 2, 3…………….n) n represents the total number of respondents. Each individual i belongs to one of the four groups.
- **Xi** is a vector of exogenous variables,

- β is a conformable parameter vector, and
- The error term $\boldsymbol{\varepsilon_i}$ is independent and identically distributed as standard normal i.e.

$\boldsymbol{\varepsilon_i} \sim NID\ (0, 1)$

Taking the value of 3 if the individual was losing more than 25% and 1 if the individual losing less than 5%, the implied probabilities are obtained as:

Pr {Qi = 1| Xi} = $\Phi\ (-_i\beta)$,

Pr {Qi = 2| Xi} = $\Phi\ (\mu_2 - {}_i\beta\ ) - \Phi\ (\mu_1 - {}_i\beta\ )$,

Pr {Qi = 3| Xi} = $\Phi\ (\mu_3 - {}_i\beta\ ) - \Phi\ (\mu_2 - {}_i\beta\ )$,

Where μ is the unknown parameter that is evaluated jointly with β. The greatest likelihood at which those mentioned probabilities enter the likelihood function serves as the basis for estimation. The fundamental latent variable model in the above equation is used to understand the βcoefficients.

The probability of the farmer's postharvest losses lying less than 5% can be written as:

$$\Pr\ (Qi = 1) = \Phi\ ({}_i\beta_1)\ \ldots\ldots\ldots\ldots\ldots\ldots$$

Where Φ (·) is the cumulative distribution function (CDF) of the standard normal (Verbeek, 2008).

It is possible to determine the measure of goodness of fit by computation:

$$\rho^2 = 1\text{- } [\ln L_b / \ln L_o]\ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$$

Where ln L_o represents the log likelihood calculated at zero and $\ln L_b$ represents the log likelihood at convergence. The limits of this measure are one and zero. The measure is 0 if every model coefficient is zero. Even though $\boldsymbol{\rho}^2$ are not equal to one, a number around one denotes an excellent match. $\boldsymbol{\rho}^2$ rises as the model fit gets better. Nevertheless, there is no intuitive way to understand the two values between zero and one (Greene, 2003).

An additional comparable non-formal goodness of fit indicator that accounts for the quantity of parameters assessed is:

$$\rho^2 \text{ bar} = 1\text{- } [\ln L_b\ K / \ln L_o]\ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$$

Where, K is the model's total number of parameter estimations (degrees of freedom).

Regression Model Diagnostics

Using the R-squared measures of fit and F-tests, the average significance of the regression models was assessed. The regression model's multicollinearity was also examined. STATA 18 software was used to assess the degree of multicollinearity. In order to test for multicollinearity, the Ordinary Least Squares regression (OLS) first looked at variance inflation factors (VIFs) from a correlation matrix (Gujarati and Porter, 2009). Heteroscedasticity in the regression model was corrected by using robust standard errors.

Variables used in regression model

Table 3.8 Explanatory variables used in regression model

Variable	Measurement	Expected Sign
Age of the respondents	Number of years	+/-
Education Qualification	Level of education	-
Method of harvesting	D =1 if Yes; 0 = otherwise	+/-
Family size	D=1 if Nuclear; 0 = otherwise	+/-
Land holding capacity	Hectares	+
Farming Experience	Number of Years	-
Distance to the market	D=1 if Yes; 0 = otherwise	+
Time of Harvest	D=1 if morning; 0 = otherwise	+
PHH training	D =1 if Yes; 0 = otherwise	-
Type of packaging	D =1 if Yes; 0 = otherwise	+/-
Time of sale	D =1 if Yes; 0 = otherwise	+
Storage facility	D =1 if Yes; 0 = otherwise	+
Labour used for harvesting	D =1 if Yes; 0 = otherwise	+
Access to market information	D =1 if Yes; 0 = otherwise	-

In the econometric models, the dependent variables included the amount of lost tomatoes, green peas, and cabbage. The dependent variables used within the regression models are described in Table 3.9.

Table 3.9 Dependent variables used in regression model

Variable	Measurement
Quantity of tomato lost	1 = Less than 5% 2 = 5 to 25% 3 = more than 25%
Quantity of cabbage lost	
Quantity of green pea lost	

g) Principal Component Analysis

To achieve second objective, Principal Component Analysis (PCA) was used. It is a statistical techniques used to facilitate the easy analysis of multivariate data. The important variable of farm management practices adopted by farmers during marketing of vegetables to reduce post-harvest losses was evaluated by Principal Component Analysis Method. These additional variables are obtained in decreasing order of significance from the original variables, which are linear combinations, in order to maximize the amount of variance in the original data that can be explained by the first principal components. Principal component analysis is the most conventional and well-known method for analyzing multivariate data. It was first used by Pearson in 1901 and developed by Hotelling in 1933. Principal component analysis (PCA) is a statistical technique aimed at reducing the dimensionality of a dataset comprising numerous connected variables, while preserving a significant amount of the dataset's volatility (Mishra *et al.,* 2017 and Domagalska-Gredys, 2020). Dimension reduction involves creating new linear combinations of dataset variables to maximize the original variance-covariance/correlation structure (Singh and Singh, 2020).

The principle components method's goal is to construct a factor from a given set of variables.

X_j's (j = 1, 2… k) of new variables (P_i), called principal components which are linear combinations of the X_s

$$P_1 = a_{11} X_1 + a_{12} X_2 + ... + a_{1k}X_k$$

$$P_2 = a_{21} X_1 + a_{22} X_2 + ... + a_{2k}X_k$$

$$. \quad . \quad . \quad .$$

$$. \quad . \quad . \quad .$$

$$P_k = a_{k1} X_1 + a_{k2} X_2 + ... + a_{kk}X_k$$

The method is being applied mostly by using standardized variables, i.e.

$$z_j = (X_j - \overline{x}_j)^2 / \sigma_j.$$

The a_{ij}'s referred to as loadings and, are calculated so that the extracted principal components meet two requirements:

P_k's means Principal components are uncorrelated (orthogonal)

The highest variance is found in the first principal component (p_1), which is followed by the second principal component (p_2), and so on (Kothari, 2004 and Mishra *et al.,* 2017).

Terminologies of Principal Component Analysis

It involves many terminologies which presented below:

i) Correlation coefficient matrix

The original dataset's correlation coefficients between different pairs of input variables are displayed in this matrix

ii) Factor loading

Factor-loadings are those numbers that indicate the degree to which the variables are connected to each identified factor. Factor-loadings actually serve as a crucial component in understanding the significance of the components (Kothari, 2004).

$L_i (j)$ is the factor loading of the variable *j* on the factor *i*.

Where,

$i = 1, 2, 3, \ldots\ldots, n$ and $j = 1,2,3,\ldots\ldots n$.

iii) Kaiser-Meyer- Olkin (KMO) test

The Kaiser-Meyer-Olkin (KMO) test determines if data is suitable for factor analysis. The test assesses the sampling sufficiency of each variable in the model as well as for the overall model. The range of the KMO value varies from 0-1 where the factorial simplicity levels of the Kaiser Index is as follows: (1 to 0.9) suggest that the sample is very good, (0.8 to 0.9) good and (0.7–0.8) medium, (0.6 to 0.7) reasonable, 0.5 to 0.6 acceptable and <0.5 suggests sampling is inadequate (Shreshtha, 2021; Pathania, 2022; Costales *et al.,* 2022). KMO values less than 0.5 imply inadequate sampling. Values near to 0 indicate that there are significant partial correlations relative to the sum of correlations (Reddy and Kulshrestha, 2019).The formula can be expressed as

$$\mathbf{KMO_j = \sum_{i \neq j} R_{ij}^2 / \sum_{i \neq j} R_{ij}^2 + \sum_{i \neq j} U_{ij}^2}$$

Where,

R_{ij}= Correlation matrix

u_{ij} = Partial covariance matrix

iv Bartlett's test of Sphericity

This hypothesis is tested to see if the correlation matrix is an identity matrix, which would imply that the variables are unrelated and thus unsuitable for structure detection. This test is frequently carried out to confirm that a data reduction technique can indeed compress the data in a meaningful way before we employ it, such as principle components analysis. The data reduction method is appropriate for our data if the p-value from the Bartlett's test of sphericity is less than the specified significance level 0.10, 0.05, and 0.01 (Reddy and Kulshrestha, 2019).

v) Communality

Communality is represented as h^2,is a measure of how much of each variable can be explained by the combined effect of the underlying factors. A high value of communality indicates proper fitting of data and if low value of communality shows that the variable are not suitable for factor analysis. It is calculated as follows with regard to each variable:

$$h^2 \text{ of the } i^{th} \text{ variable} = (i^{th} \text{ factor loading of factor A})^2 + (i^{th} \text{ factor loading of factor B})^2 + \dots$$

The communalities for the i^{th} variable are computed by taking the sum of the squared loading for that variable as expressed below:

$$\mathbf{h_i}^2 = \sum_{j=1}^{n} lij2$$

vi) Eigen Value

Eigen value is a measure of how significant each component is in explaining the specific set of variables under investigation (Kothari, 1990). Eigen values are a reflection of the data's qualities, demonstrating the communality of that particular component and all of the data. If no factor is eliminated, the total of the communalities of all variables equals the sum of the squares of the eigen values of all the factors. The sum of squares representing the factor loading of every variable on a factor represents the eigenvalue of a vector (Mishra *et al.,* 2017 and Pathania, 2022).

$$j = \sum_{i=1}^{n} L_{ij}{}^2$$

vii) Rotation

Factor analysis uses rotation to reveal different structures in the data through different rotations. In statistical terms, all results are considered equal, regardless of how differently a particular rotation seems to have produced the desired results. However, comprehending the factor analysis results requires selecting the right rotation. The process of interpreting the factors will be made easier if there is a simple structure. In case no simple structure exists, the factors' n-dimensional space should be rotated by an angle such that the factor loadings are revised to create a simple structure. This kind of rotation is referred to as factor rotation. There are two types of rotation of factors:

Varimax: The varimax method is an oblique rotation that occurs when factors are independent.

Promax: The promax method is an orthogonal rotation that is used when factors are interrelated.

For the present study, varimax method has been used via SPSS statistical package (Kothari, 2004 and Pathania, 2022).

g) Multiple response analysis

A single observation's response may be divided into several categories when respondents are given the opportunity to choose various options. As a result, in multiple response analysis, the total number of replies typically exceeds the entire number of analysis units (Lavassani *et al*., 2009 and Jann, 2005). The data was statistically evaluated using the SPSS 26 program, and the information that was gathered was divided into two categories: the frequency of replies and the percentage of responses for the supplied questions.

Constraint Analysis and Suggestion

For the purpose of achieving the final objective of identify the key constraints and suggest management intervention for managing post-harvest losses during marketing of vegetable crops in the study area, mean score were calculated. Using this methodology, the farmers in the sample were asked to rate each of the categories of constraints that were presented to them on a 5-point Likert scale. All of the components' mean scores were ordered in decreasing order, and the elements that had the greatest mean value score were ranked as the primary constraints faced by the sampled farmers in the research area. This allowed for the identification of the most influential factors.

h) Kendall's Coefficient of Concordance (KCC)

A non-parametric test called Kendall's W statistic (Coefficient of Concordance) was used to evaluate the degree of agreement between the listed limitations that the farmers in the research area faced. The results ranged from 0 (no agreement) to 1 (total agreement).It is a measurement of the degree of agreement between several raters who are assessing a particular set of n things (Kothari, 2005; Gearhart, 2013; Kwame *et al*., 2020; Gearhart *et al.*, 2013 and Legendre, 2005).

In this study, farmers' agreement on the obstacles they faced during post-harvest losses has been evaluated using Kendall's coefficient of concordance. The following is an expression for Kendall's coefficient of concordance:

$$\frac{s}{\frac{1}{12}k^2\,(N^3 - N)}$$

Where,

$s = \sum (R_j - \bar{R}_j)^2$

k = number of sets of rankings i.e., the number of judges;

N = number of constraints being ranked;

$\frac{1}{12}k^2\,(N^3 - N)$ = The sum (s) which would occur with perfect agreement among (k) rankings

The following theory was examined in relation to the constraints:

H_0 = Farmers disagree about the difficulties they encounter during marketing of vegetable crops

H_1 = Farmers generally agree about the challenges they experience during marketing of vegetable crops

i) Relative Importance Index

For data with ordinal attitude evaluation, a well-liked non-parametric technique for assessing structured questionnaire responses is the Relative Importance Index (RII). Relative Importance Index (RII) for each element were created by taking the five-point Likert scale, which ranges from 1 (extremely low important) to 5 (very high important) and applied to rank the respondents' feedback (Tarek *et al.,* 2022, Sakhare and Patil, 2019, Khaleel and Nassar, 2017, Tholibon et al. 2021).

Relative Importance Index is calculated as shown in equation.

$$\mathbf{RII} = \frac{\sum W}{AN}$$

Where:

W : is the weighting given to each indicator by the respondents (ranging 1-5),

A : is the highest weight (i.e. 5 in this case), and

N : is the total number of respondents.

The RII value has a range from 0 to 1 (0 not inclusive) and has been categorized into five levels of importance as shown in Table 3.10.

Table 3.10 Representation of Relative Index Value Range

RII Value	**Importance level**	
From 0.8 to 1	High	(H)
From 0.6 to 0.8	High-Medium	(H-M)
From 0.4 to 0.6	Medium	(M)
From 0.2 to 0.4	Medium-Low	(M-L)
From 0 to 0.2	Low	(L)

Chapter-4

RESULTS AND DISCUSSION

The primary and secondary data collected from the respondents was analyzed with various statistical tools and the results concerning study objectives are provided along with detailed discussions. This chapter primarily focuses on the factors that affect the post-harvest losses, and the constraints that farmers faced during marketing of selected vegetable crops in Himachal Pradesh. Further this chapter is divided into following sections as given below:

4.1 General description of the Himachal Pradesh

Section A: Socio-economic Profile

4.2 General demographic profile of the respondents

4.3 Demographic profile of the respondents as per the study area

Section B: Existing status of post-harvest losses of selected vegetable crops

4.4 Trend and Growth in area, production and yield over time

4.5 Status and stages of post-harvest losses in selected vegetable crops

Section C: Factor affecting post-harvest losses of farmers during marketing of selected vegetable crops

4.6 Factor affecting post-harvest losses during marketing of selected vegetable crop

4.7 Various field-to-market-level loss conditions which leads maximum damage to selected vegetable crops

4.8 Management practices adopted by the farmers during marketing of vegetables to reduce post-harvest losses

4.9 Information source used by farmers to adopt farm management practices to reduce PHL

Section D: Major constraints and suggestion for marketing and reducing post-harvest losses of selected vegetable crop

4.10 Constraints faced by the farmers for marketing of selected vegetable crops in the study area

4.11 Farmers suggestion for managing the post-harvest losses of selected vegetable crops in the study area

4.1 General description of the Himachal Pradesh

The northern state of India is called Himachal Pradesh, or the "Province of the Snow-laden Mountains" located in western Himalayas. Himachal Pradesh is one of the eleven mountain states, is distinguished by a harsh terrain with numerous peaks and vast river networks. Himachal Pradesh is situated between the longitudes of 75° 04' 55" and 79° 04' 20" East and the latitudes of 30° 22' 40" and 33° 12' 40" North, with the elevations ranging from 350 to 7000 m above sea level. The total geographical area of the state is 55,673 km^2 out of 37,033 km^2 is covered by forest. The state covers 55.67 lakh hectares in total out of which 9.55 lakh hectares are net planted. The state's agricultural sector is defined by the large number of small and marginal farmers who have an average of one hectare of land. It is the largest fruit exporting state in the nation and referred as India's "fruit bowl." Himachal Pradesh is an agriculture state as 71 per cent of the population directly or indirectly depends on agriculture and contributes 13.62 per cent in total state domestic product (DoA, Government of Himachal Pradesh, 2022; Pathania, 2022 and Sharma, 2022).

4.1.1 General description of the district Mandi in Himachal Pradesh

Mandi is a Hindi word, which means "market," may have its origins in the Sanskrit word "mandapika," which means "an open hall or shed." It may also have been derived from the Sanskrit word mand, which means "to adorn or distribute." Mandi district was created on April 15, 1948, when two princely states Mandi and Suket merged to establish the state of Himachal Pradesh. Mandi is one of the twelve district of Himachal Pradesh located in the western Himalayas the latitudes of 31°13'20" and 32°04'30" North and the longitudes of 76°37'20" and 77°23'15" East. The district has been divided administratively into 10 blocks and 6 subdivisions with a total geographical area of 3,950 square km; the district comprises approximately around 7% of the state's total land area and receives the highest average annual precipitation of 1,568.5 mm in the state. The district contains regions that range in elevation from higher mountains to low-lying subtropical zones, allowing for the production of a wide range of field crops, fruits, and animal companies. In terms of area and productivity, the district's major vegetable crops are the tomato, peas, cabbage, cauliflower, cucurbits, onion, and garlic. The agricultural situation is particularly distinctive and complicated as more than half of the population in the Mandi district depends on agriculture for their livelihood (DoA, District Agriculture Plan, 2009).

4.1.2 General description of the district Solan in Himachal Pradesh

Solan became an independent district on 1 September 1972. The district is bordered by the districts of Shimla in the north, Punjab and Haryana in the south, Sirmour in the east, Bilaspur in the west, and Mandi in the north-east. The district is located in Zones I and II, which encompass low- to mid-hill terrain and lies between 30°30' and 30° 15' North latitude and 76° 42' to 77°20' East longitude. The district is 3,000-3,000 meters above mean sea level and is divided into five development blocks. The district spans a total geographical area of 1,936 square km and receives an average annual rainfall of 1420.40 mm. The district grows a large amount of maize, wheat, tomatoes, peas, capsicums, cauliflower, broccoli, cabbage, ginger, and garlic. In addition, the territory has a high level of mushroom cultivation. All kinds of temperate and sub-temperate fruits, such as apricot, plum, pear, mango, banana, grapes, and kiwi, among others, are well-suited to grow in the district due to its climate and topography. The majority of the local population is employed in agriculture, and they follow a number of customs that make farming on sloping terrain easier (DOA, District Agriculture Plan, 2009; Sharma, 2022).

4.1.3 General description of the district Shimla in Himachal Pradesh

The Shimla district came into existence on 1 September 1972, located in Himachal Pradesh's humid temperate zone which is situated between latitude 300 and longitudes 77° and 78° east. The district is encircled by the districts of Sirmour in the south, Solan in the west, Kinnaur in the east, and Mandi and Kullu in the north. Shimla has 7 subdivisions, 11 tehsils, 6 sub- tehsils and 10 developmental blocks. The climate ranges from moderate to alpine, with the warm season occurring in low-lying places. The district total geographical area is 5,131 square kilometres of the state's total area. Crop cultivation differs depending on the area's elevation and location as the elevation varies from 600 meters above sea level in Tata Pani to 5,760 meters above sea level at Gushu Pishu. There are severe hills and mountains throughout the entire area. Agro climatically, the area is better suited for cultivating temperate fruits and vegetables that are in season later in the year. Along with other temperate fruits and medicinal plants, the main crops farmed in the district are apples, wheat, maize, and vegetables (DOA, District Agriculture Plan, 2009; Pathania, 2022; Sharma, 2022).

Section A: Socio-economic Profile

4.2 Demographic profile of respondent

The demographic analysis provides a general overview of the demographic and socio-economic characteristics like gender, age, education qualification, occupation, income status, land holding capacity etc. of the respondent

4.2.1 Gender of the respondents

Gender profile of the respondents is shown in Table 4.1.

Table 4.1 Gender of the sampled farmers

Gender	Frequency	Percentage
Male	264	73.3
Female	96	26.7
Total	**360**	**100.0**

Source: Field Survey, 2022-23

Tables 4.1 showed that, majority of the respondent in the study area were male with 73.3 per cent and female with 26.7 per cent. The result revealed that maximum numbers of the males were involved in farming as compared to the females.

4.2.2 Age status of the respondents (in Years)

Table 4.2 is shown the age status of the respondents.

Table 4.2 Age status of the sampled farmers (in Years)

Age (year)	Frequency	Percentage
Less than 18	2	0.6
19-35	91	25.3
35-50	169	46.9
Above 50	98	27.2
Total	**360**	**100.0**

Source: Field Survey, 2022-23

Table 4.2 depicted the age distribution of the farmers in the research area. The findings showed that the majority of the farmers were between the age of 35-40 (46.9 %) followed by above 50 (25.2 %), 19-35 (25.3 %) and least in less than 18 (0.6 %).

4.2.3 Educational status of the respondents

Educational status of the farmers is shown in Table 4.3.

Table 4.3 Educational status of the sampled farmers

Educational Qualification	Frequency	Percentage
Up to 10th	127	35.3
Up to graduation	151	41.9
Post-graduation and above	62	17.2
Professional qualified	20	5.6
Total	**360**	**100.0**

Source: Field Survey, 2022-23

In table 4.3, the educational qualification of the respondents at the overall level showed that majority of the respondents had their education up graduation (41.9 %) followed by respondents that had their education up to 10th (33.3 %), 17.2 per cent respondents had their post-graduation and above and only 5.6 per cent respondents were professional qualified in the study area.

4.2.4 Occupational status of the respondents

Table 4.4 is shown the occupational status of the respondents.

Table 4.4 Occupational status of the sampled farmers

Occupational Status	Frequency	Percentage
Farming as main profession	165	45.8
Farming with subsidiary Profession	99	27.5
Private job	33	9.2
Government job	44	12.2
Retired	19	5.3
Total	**360**	**100.0**

Source: Field Survey, 2022-23

The data presented under the table 4.4 showed that, in the research area farming as main profession is the major occupation (45.8 %) of sampled farmers and 27.5 per cent farmers have opted farming with subsidiary profession followed by government job with 12.2

per cent, private job with 9.2 per cent and the respondents that had retired were 5.3 per cent in the study area.

4.2.5 Income status of the respondents

Income status of the sampled farmers in the study area is shown in Table 4.5.

Table 4.5 Income status of the sampled farmers (Rs/annum)

Income Status (Rs/ annum)	Frequency	Percentage
Less than 5 lakhs	154	42.8
5-10 lakhs	150	41.7
10-15 lakhs	36	10.0
Above 15 lakhs	20	5.6
Total	**360**	**100.0**

Source: Field Survey, 2022-23

It is reported from the Table 4.5 that 42.8 per cent of the respondents had less than 5 lakhs Rs/annum income followed by 41.7 per cent respondents in between 5-10 lakhs Rs/ annum, 10.0 per cent respondents in between 10-15 lakhs Rs/annum income and 5.6 per cent of the respondents have income i.e. above 15 lakhs Rs/annum.

4.2.6 Family type of the respondents

Tables 4.6 represent the family structure of the respondents.

Table 4.6 Family structure of the sampled farmers

Family Type	Frequency	Percentage
Nuclear	267	74.2
Extended	93	25.8
Total	**360**	**100.0**

Source: Field Survey, 2022-23

It is observed from Table 4.6 that the majority of the sampled farmers (74.2 per cent) belonged to the nuclear families and 25.8 per cent of sampled farmers had extended families in the research area.

4.2.7 Land holding capacity of the respondent

Land holding capacity of the respondents in the study area is shown in Table 4.7.

Table 4.7 Land holding of the sampled farmers (in Hectare)

Land Holding	Frequency	Percentage
Marginal (0-1ha)	93	25.8
Small (1-2ha)	206	57.2
Semi medium (2-4ha)	53	14.7
Medium (4-10ha)	8	2.2
Large (above 10ha)	-	-
Total	**360**	**100.0**

Source: Field Survey, 2022-23

It is noticeable from Table 4.7 that 57.2 per cent of the sampled farmers in the study area had small land holding (1-2 ha) followed by 25.8 per cent of the farmers were marginal land holders and 14.7 per cent of the farmers belonged to semi medium land holding (2-4 ha). The result also revealed that only 2.2 per cent of the respondents were medium land holder (4-10 ha) whereas, no farmer belonged to the large land holding i.e. (above 10 ha) in the research area.

4.2.8 Experience status of the respondents

Table 4.8 is shown the experience of the sampled farmers in the research area.

Table 4.8 Experience status of the sampled farmers

Experience Status	Frequency	Percentage
Less than 5 years	25	6.9
5-10 years	71	19.7
10-15 years	121	33.6
Above 15 years	143	39.7
Total	**360**	**100.0**

Source: Field Survey, 2022-23

Table 4.8 depicted that the farmers of the study area had good farming experience. The result revealed that, 39.7 per cent of the respondents had above 15 years' experience in the farming followed by 33.6 per cent who had (10-15 years) and 19.7 per cent of the respondents who had (5-10 years) of farming experience. Overall, only 6.9 per cent of the respondents have less than 5 years' experience in the farming.

4.3 Demographic profile of the respondents as per the study area

Demographic profile is a measurement of social and economic status of an individual person or a group with others in society. The present study investigates the socio-economic characteristics such as gender, age, education, income etc. These characteristics had significant impact on farmer's wellbeing and improve their security. These socio-economics characteristics also improve the farm management decision making and marketing process.

4.3.1 Gender of the respondents in the study area

Gender analysis provide a perspective on how socially constructed roles and duties affect rang of agricultural decisions related to production, processing, market participation, consumption and well-being of an individuals. Table 4.9 is shown the detailed description of the sample farmers in the study area.

Table 4.9 Gender description of sampled farmers in the study area

Gender	Solan	Mandi	Shimla	Overall
Male	89 (74.2)	87 (72.5)	88 (73.3)	264 (73.3)
Female	31 (25.8)	33 (27.5)	32 (26.7)	96 (26.7)
Total	**120 (100.0)**	**120 (100.0)**	**120 (100.0)**	**360 (100.0)**

Note: Figure in parentheses represents per cent to the total *Source: Field Survey, 2022-23*

It is reported from Table 4.9 that at an overall level, the proportion of males with 73.3 per cent was higher than that of female with 26.7 per cent in the study area. The result found that male respondents played important role in farming, especially in study area.

4.3.2 Age status of respondents in the study area

In terms of carrying out various tasks related to agriculture, the respondent's age defines how a farmer contributes to farming. Young individuals are more likely to choose new technology, whereas older individuals prefer to continue with long-standing customs. As a result, analyzing the respondents' ages allows us to assess their ability for making appropriate decisions. Age-wise status of the sampled farmers is shown in Table 4.10.

Table 4.10 showed that the majority of the farmers i.e. 46.9 per cent were between (35-50 years) age groups in the study area followed by others age group. The maximum number of sampled farmers in Solan district (44.2 %) belonged to (35-50 years) age group followed by 28.3 per cent in (19-35 years) age group and 25.8 per cent were belonged to (above 50 years) age group. In the Mandi district, the majority of the farmers i.e. 50.8 per cent were between the (35-50 years) age group and about 31.7 per cent belonged to above 50 years followed by 17.5 per cent farmers were between the (19- 35 years) age group. The scenario of Shimla district showed that 45.8 per cent farmers were belonged to (35-50 years) age group followed by above 50 years age group i.e. 24.2 per cent and 30.0 per cent farmers were between (19-35 years) age group. It was concluded that (35-50 years) age group of sampled farmers were highly engaged in farming as compared to other age group in the study area.

Table 4.10 Description of age status of sampled farmers in the study area (in years)

Age (year)	Solan	Mandi	Shimla	Overall
Less than or equal to 18	2 (1.7)	-	-	2 (0.6)
19-35	34 (28.3)	21 (17.5)	36 (30.0)	91 (25.3)
35-50	53 (44.2)	61 (50.8)	55 (45.8)	169 (46.9)
Above 50	31 (25.8)	38 (31.7)	29 (24.2)	98 (27.2)
Total	**120 (100.0)**	**120 (100.0)**	**120 (100.0)**	**360 (100.0)**

Note: Figure in parentheses represents per cent to the total *Source: Field Survey, 2022-23*

4.3.3 Educational status of the respondents in the study area

Education is a potential source of the knowledge needed to comprehend instructions and access new technological information. Education plays a significant role in farm management decision-making and in the adoption of innovative agricultural technologies to prevent post-harvest losses. As a result, it is critical to assess farmers' knowledge levels in order to understand their information-seeking behavior, decision-making abilities, and initiative in adopting new technologies. Detailed description of the sampled farmers is shown in the Table 4.11.

It is revealed from Table 4.11 that the education rate of the sampled farmers at the overall level, majority of the farmers in the study area had their education up to graduation (41.9 %). The education rate of Solan district showed that 45.0 per cent sampled farmers were graduated followed by 23.3 percent of farmers had their education up to 10th, 22.5 per cent of framers were post-graduated and only 9.2 per cent of farmers were professional qualified. In Mandi district, 44.2 per cent and 36.7 per cent of farmers were graduated and studied up to 10th respectively and only 3.3 per cent farmers were professional qualified. The scenario of Shimla district revealed that majority of sample farmers i.e. 41.9 per cent were graduated and 35.3 per cent were had their 10th followed by 5.6 per cent who were professional qualified in the study area. The findings showed that the research area's education rate was very high, which meant that the sampled farmers were well-equipped to adopt new technologies and have access to market information from a variety of sources.

Table 4.11 Detailed description of educational status of sampled farmers in the study area

Educational Status	Solan	Mandi	Shimla	Overall
Up to 10th	28 (23.3)	44 (36.7)	55 (45.8)	127 (35.3)
Up to graduation	54 (45.0)	53 (44.2)	44 (36.7)	151 (41.9)
Post-graduation and above	27 (22.5)	19 (15.8)	16 (13.3)	62 (17.2)
Professional qualified	11 (9.2)	4 (3.3)	5 (4.2)	20 (5.6)
Total	**120 (100.0)**	**120 (100.0)**	**120 (100.0)**	**360 (100.0)**

Note: Figure in parentheses represents per cent to the total *Source: Field Survey, 2022-23*

4.3.4. Occupational status of the respondents in the study area

Occupation is a crucial predictor of a person's social position, as it also reflects the family's economic condition and level of living. The occupation status of sampled farmers is shown in the Table 4.12.

Table 4.12 Description of occupational status of sampled farmers in the study area

Occupational Status	Solan	Mandi	Shimla	Overall
Farming only profession	52 (43.3)	46 (38.3)	67 (55.8)	165 (45.8)
Farming (with subsidiary profession)	43 (35.8)	40 (33.3)	16 (13.3)	99 (27.5)
Private job	10 (8.3)	11 (9.2)	12 (10.0)	33 (9.2)
Government job	11 (9.2)	16 (13.3)	17 (14.2)	44 (12.2)
Retired	4 (3.3)	7 (5.8)	8 (6.7)	19 (5.3)
Total	**120 (100.0)**	**120 (100.0)**	**120 (100.0)**	**360 (100.0)**

Note: Figure in parentheses represents per cent to the total *Source: Field Survey, 2022-23*

It is observed from the above Table 4.12 that in the study area farming was done as primary profession i.e. 45.8 per cent followed by 27.5 per cent farmers done farming with other profession. Among the entire selected district (Solan, Mandi and Shimla) majority of sampled farmers had done farming as main profession (43.3 %, 38.3 % and 55.8 %) followed by farming with subsidiary profession i.e. 35.8 per cent, 33.3 per cent and 13.3 per cent. Further, this was followed by government job, private job and retired farmers who opt farming after their retirement. Therefore, it concluded that the majority of sampled framers' primary occupation in the research area was farming.

4.3.5 Income status of respondents in the study area

The income of a family is a significant factor in determining the socioeconomic status of an individual. The data related to annual income of sampled farmers is reported in the Table 4.13.

Table 4.13 Description of annual income status of sampled farmers in the study area

Income (Rs./Annum)	Solan	Mandi	Shimla	Overall
Less than 5 lakhs	67 (55.8)	42 (35.0)	45 (37.5)	154 (42.8)
5-10 lakhs	41 (34.2)	59 (49.2)	50 (41.7)	150 (41.7)
10-15 lakhs	9 (7.5)	14 (11.7)	13 (10.8)	36 (10.0)
Above 15 lakhs	3 (2.5)	5 (4.2)	12 (10.0)	20 (5.6)
Total	**120 (100.0)**	**120 (100.0)**	**120 (100.0)**	**360 (100.0)**

Note: Figure in parentheses represents per cent to the total *Source: Field Survey, 2022-23*

The income status of the sampled farmers in Table 4.13 showed that at the overall level, majority of the farmer's i.e. 42.8 per cent annual income was less than 5 lakhs and least belonged to above 15 lakhs of annual income i.e. 5.6 per cent. The income status of Solan district showed that most of sampled farmers i.e. 55.8 per cent belonged to less than 5 lakh annual incomes followed by 34.2 per cent of sampled respondents has 5 to 10 lakhs, 7.5 per cent had 10 to 15 lakhs and the least belonged to above 15 lakhs of annual income with 2.5 per cent. In Mandi district majority of the sampled farmers (49.2 %) annual income were 5-10 lakhs followed by 35.0 per cent , 11.7 per cent and least 4.2 per cent of sampled framers belonged to less than 5 lakhs, between 10-15 lakhs and least belonged to above 15 lakhs. The scenario of Shimla district showed that majority of the farmers i.e. 41.7 per cent annual income were between 5-10 lakhs followed by 37.5 per cent respondents annual income were less than 5 lakhs and least of sampled farmers i.e. 10.0 per cent belonged to above 15 lakhs annual income.

4.3.6 Family type of respondents in the study area

Table 4.14 is shown the family structure of the samples farmers in the study area.

Table 4.14 Description of family type of sampled farmers in the study area

Family Type	Solan	Mandi	Shimla	Overall
Nuclear	91 (75.8)	78 (65.0)	98 (81.7)	267 (74.2)
Extended	29 (24.2)	42 (35.0)	22 (18.3)	93 (25.8)
Total	**120 (100.0)**	**120 (100.0)**	**120 (100.0)**	**360 (100.0)**

Note: Figure in parentheses represents per cent to the total *Source: Field Survey, 2022-23*

The above Table 4.14 concluded that family structure of sampled farmers in the study area consist 75.8 per cent nuclear families followed by 24.2 per cent extended families in Solan District. In Mandi district majority of the families (65.0 %) belonged to the nuclear families followed by extended families i.e. 35.0 per cent. At last it was showed in Table 4.14 that in Shimla district also most of the families were belonged to the nuclear families (81.7 %) and 18.3 per cent families respondents belonged to the extended families. According to the results in the table, family structure has a significant impact on whether or not a person engages in agricultural activities that would secure their well-being and livelihood.

4.3.7 Land holding capacity of respondents in the study area

The most valuable resource in the agriculture sector is land, which can provide the most for farmers through a variety of farming activities. These actions have a direct impact on farmers' farm income, savings, and investment status. Land holding capacity is crucial in establishing the farmers' revenue potential and for understanding the extent to which agricultural inputs are used in the studied area. Land holding capacity of sampled farmers is shown in the Table 4.15.

Table 4.15 Description of land holding of sampled farmers in the study area

Land holding	Solan	Mandi	Shimla	Overall
Marginal (0-1ha)	52 (43.3)	6 (5.0)	35 (29.2)	93 (25.8)
Small (1-2ha)	59 (49.2)	76 (63.3)	71 (59.2)	206 (57.2)
Semi medium (2-4ha)	8 (6.7)	35 (29.2)	10 (8.3)	53 (14.7)
Medium (4-10ha)	1 (0.8)	3 (2.5)	4 (3.3)	8 (2.2)
Large (above 10ha)	-	-	-	-
Total	**120 (100.0)**	**120 (100.0)**	**120 (100.0)**	**360 (100.0)**

Note: Figure in parentheses represents per cent to the total *Source: Field Survey, 2022-23*

Table 4.15 depicted that majority of the sampled farmers' belonged to small land holding (1-2 ha) i.e. 49.2 per cent followed by marginal farmer (43.3 %), 6.7 percent sampled farmers belonged to the semi medium (2-4 ha) land holding in Solan district, whereas none of sampled farmers belonged to the large (above 10 ha) land holding in selected (Solan, Mandi and Shimla) district. In the scenario of Mandi and Shimla district also most of the sampled farmers (63.3 and 59.2 %) belonged to the small (1-2 ha) land holding. Further, 63.3 per cent samples farmers were semi medium (2-4 ha), (5.0 %) were marginal farmers and 2.5 per cent were belonged to the medium (4-10 ha) land holding in Mandi district. At last in Shimla district 29.8 per cent sampled farmers were marginal, 8.3 per cent were semi medium and 3.3 per cent farmers were belonged to the medium(4-10 ha) land holding.

4.3.8 Experience status of respondents in the study area

Experience in farming is the length of time a farmer has been engaged in farming since they began making their own independent production decisions. Farmers gather knowledge as they work and gradually replace standard farming techniques with more advanced ones based on observed results and what they have learned. Table 4.16 is shown farming experience of sampled farmers in the study area.

It is observed from Table 4.16 that at the overall level, majority of the sampled farmers had very good experience in the farming. In the study area, majority of sampled farmers in Solan district (35.8 %), in Mandi district (47.5 %) and in Shimla district (35.8 %) had above 15 years farming experience followed by 35.0 per cent sampled farmers in Solan, 33.3 per cent in Mandi and 32.5 per cent farmers in Shimla district had farming experience between 10-15 years. It is also evident from the Table 4.16 that 22.5 percent sampled respondents in Solan District, 12.5 per cent in Mandi district and 24.2 per cent sampled farmers in Shimla District had farming experience between 5-10 years. The farmers who had less than 5 years' experience in farming were 6.7 per cent in Solan, Mandi district and 6.9 per cent in Shimla district.

Table 4.16 Description of experience status of sampled farmers in the study area

Experience Status	Solan	Mandi	Shimla	Overall
Less than 5 years	8 (6.7)	8 (6.7)	9 (7.5)	25 (6.9)
5-10 years	27 (22.5)	15 (12.5)	29 (24.2)	71 (19.7)
10-15 years	42 (35.0)	40 (33.3)	39 (32.5)	121 (33.6)
Above 15 years	43 (35.8)	57 (47.5)	43 (35.8)	143 (39.7)
Total	**120 (100.0)**	**120 (100.0)**	**120 (100.0)**	**360 (100.0)**

Note: Figure in parentheses represents per cent to the total *Source: Field Survey, 2022-23*

4.3.9 Marketable surplus of respondents in the study area

The term marketable surplus describes the difference between a farmer's entire output and his own consumption of that output. To put it another way, it's the amount of produce that the farmer sells at the market. Table 4.17 is shown the detailed description of sale when produce is in surplus in the research area.

Table 4.17 Preferred sales and distribution agencies for vegetable crops

Marketable Surplus	Solan	Mandi	Shimla	Overall
Local Market	5 (4.2)	8 (6.7)	2 (1.7)	15 (4.2)
Commission Agent	47 (39.2)	44 (36.7)	60 (50.0)	151 (41.9)
APMC	56 (46.7)	45 (37.5)	51 (42.5)	152 (42.2)
Preharvest Contractor	-	14 (11.7)	4 (3.3)	18 (5.0)
Postharvest Contractor	12 (10.0)	9 (7.5)	3 (2.5)	24 (6.7)
Total	**120 (100.0)**	**120 (100.0)**	**120 (100.0)**	**360 (100.0)**

Note: Figure in parentheses represents per cent to the total *Source: Field Survey, 2022-23*

The above Table 4.17 concluded on overall basis, that majority of the respondents with the 42.2 per cent of the farmers sell their surplus in APMC where Solan has (46.7 %), Shimla has (42.5 %) and Mandi has (37.5 %) followed by 41.9 per cent sampled farmers sell their produce to Commission agent respectively where Shimla has (50.0 %), Solan has 39.2 per cent and 36.7 per cent in Mandi.. The result showed the overall status of least procurer who was Post-harvest contractor (6.7 %) i.e. Solan with 10 per cent, Mandi (7.5 %) and Shimla (2.5 %) followed by Preharvest contractor (5.0%) where Mandi contain 11.7 per cent sampled respondents, 3.3 per cent in Shimla and no sampled farmers of Solan district sell their produce to Preharvest contractor. Lastly, overall status of local market was (4.2 %) where Mandi has 6.7 per cent, Solan has 4.2 per cent and Shimla has 1.7 per cent sampled farmers who sell their produce in local market.

Section-B: Existing status of post-harvest losses during marketing of selected vegetable crops

4.4 Trend and growth of Area, Production and Productivity over the time

To determine the expansion of selected vegetable crops, an analysis of the area under cultivation of selected vegetables and the production of selected vegetable crops is conducted. The study period spans are from 2012 to 2022. The records and reports of the Directorate of Agriculture, Government of Himachal Pradesh, Shimla, were the source of the secondary data regarding the area under cultivation and output of particular crops. To investigate the trend in area, production, and productivity of tomato, cabbage, and green pea, the compound growth rate was calculated from 2012 to 2022 (Devi and Prasher, 2018; Sethi *et al*., 2022 and Bindra *et al*., 2010).

4.4.1 Trend of area under Tomato cultivation, production and productivity since 2012

Table 4.18 presented the changes areas, production and productivity of tomato crops in study area. The area under tomato crop has increased from 9.93 thousand hectares in 2012-13 to 13.75 thousand hectares in 2021-22, and tomato production has increased from 413.7 thousand metric tons in 2012-13 to 577 thousand metric tons in 2020-21. Tomato production fell by 498.3 thousand metric tons between 2021 and 2022. Fig 4.1 and 4.2 illustrate the trend of area under tomato and tomato production which revealed that area under tomato crop has gradually increased over the years. Likewise, production of tomato crop was increasing till

2021 but faced a downfall in the year 2022. Over the period of 10 years since 2012 area under tomato cultivation has grown at a compound growth rate of 3.78 per cent. The area under tomato crop for period 2012-2022 has recorded a positive growth rate. The total production has also increase with compound growth rate 2.75 per cent. Yield per hectare of tomato crop from period 2012-2022 also presented in table 4.18. The overall productivity of tomato has lower negative growth rate -1.00 per cent.

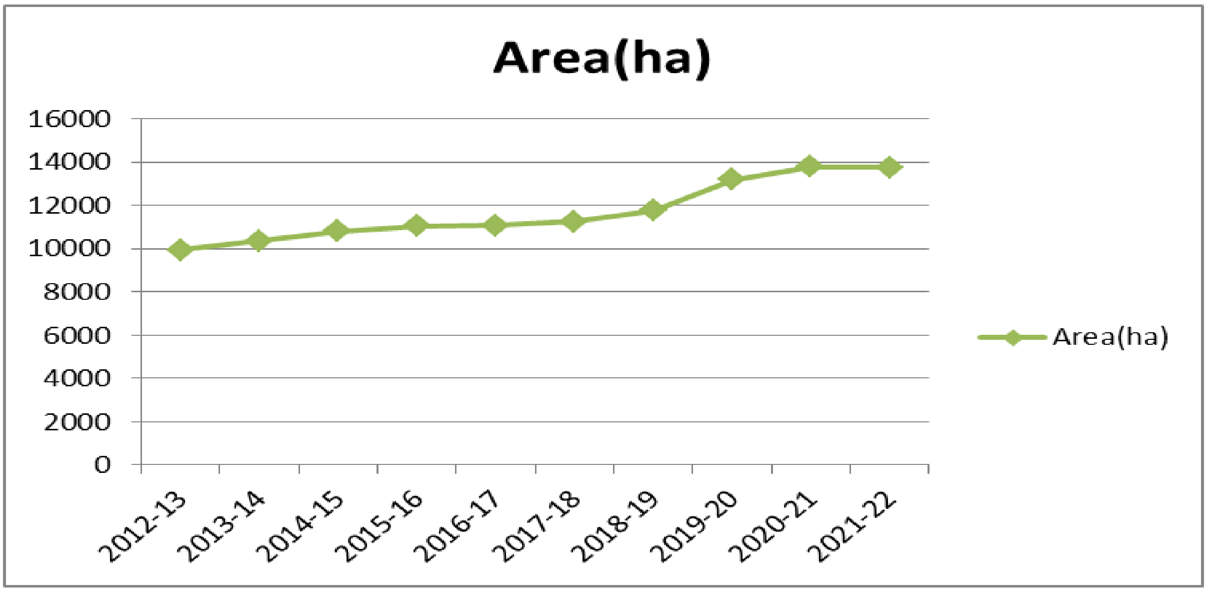
Table 4.18 Trend of Area, Production and Productivity in Tomato Crop (2012-22)

Tomato			
Year	**Area (ha)**	**Production (MT)**	**Productivity (MT/ha)**
2012-13	9930	413709	41.66
2013-14	10373	430789	41.53
2014-15	10800	475965	44.07
2015-16	11037	485536	43.99
2016-17	11064	473284	42.77
2017-18	11240	481936	42.88
2018-19	11750.2	502422	42.76
2019-20	13185.4	539540	40.91
2020-21	13795	577005	41.82
2021-22	13750.8	498358	36.24
CAGR	**3.78*****	**2.75*****	**-1.00*****

Note: *, **, *** means the coefficient is statistically significant at the 10%, 5% and 1% levels

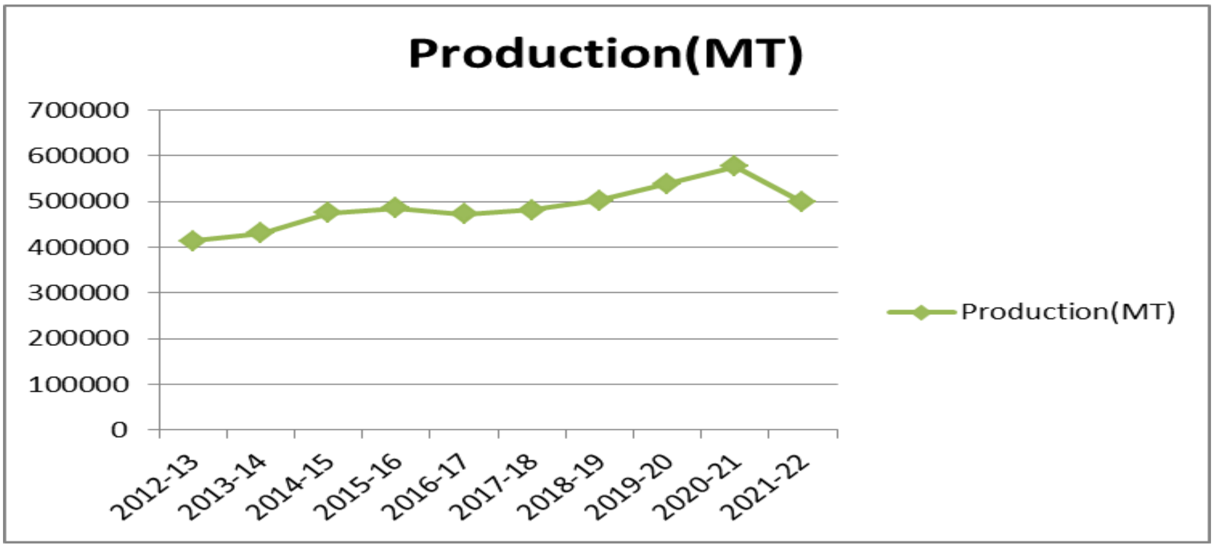
Source: HP DoA Annual Report, 2022

Figure 4.1 Area under Tomato cultivation in hectare (2012-22)



Source: HP DoA Annual Report, 2022

Figure 4.2 Production of Tomato cultivation in metric tons (2012-22)



Source: HP DoA Annual Report, 2022

4.4.2 Trend of area under Cabbage cultivation, production and productivity since 2012

Table 4.19 Trend of Area, Production and Productivity in Cabbage Crop (2012-22)

Cabbage			
Year	**Area(ha)**	**Production(MT)**	**Productivity(MT/ha)**
2012-13	4387	149671	34.12
2013-14	4560	153811	33.73
2014-15	4819	158301	32.85
2015-16	4905	160744	32.77
2016-17	4852	161108	33.2
2017-18	4903	168249	34.31
2018-19	5283	170333	32.24
2019-20	5480	177883	32.46
2020-21	4661	146659	31.46
2021-22	4617	148300	32.12
CAGR	**0.91*** **	**0.23*** **	**-0.67*** **

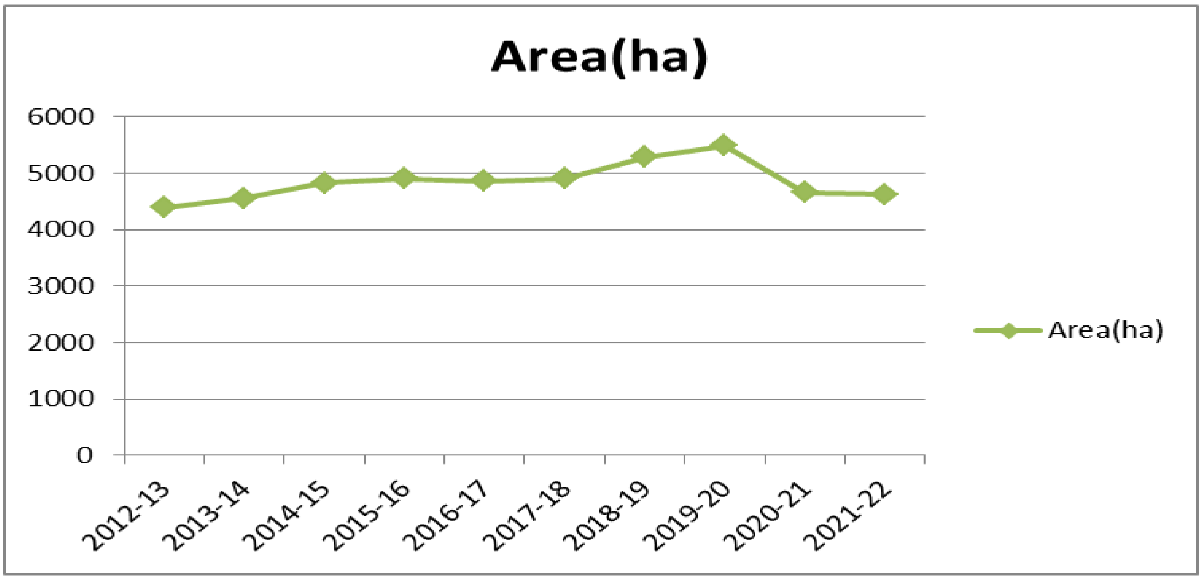
Note: *, **, *** means the coefficient is statistically significant at the 10%, 5% and 1% levels

Source: HP DoA Annual Report, 2022

The research region's variations in cabbage crop acreage, productivity, and production were shown in Table 4.19. Cabbage production increased from 149.671 thousand metric tons in 2012–13 to 177.883 thousand metric tons in 2019–20. The area under cabbage crop increased from 4.387 thousand hectares in 2012–13 to 4.167 thousand hectares in 2021–22. Between 2021 and 2022, the production of cabbage fell by 148.3 thousand metric tons. The trend line of the area under cabbage and cabbage production is shown below in the figures

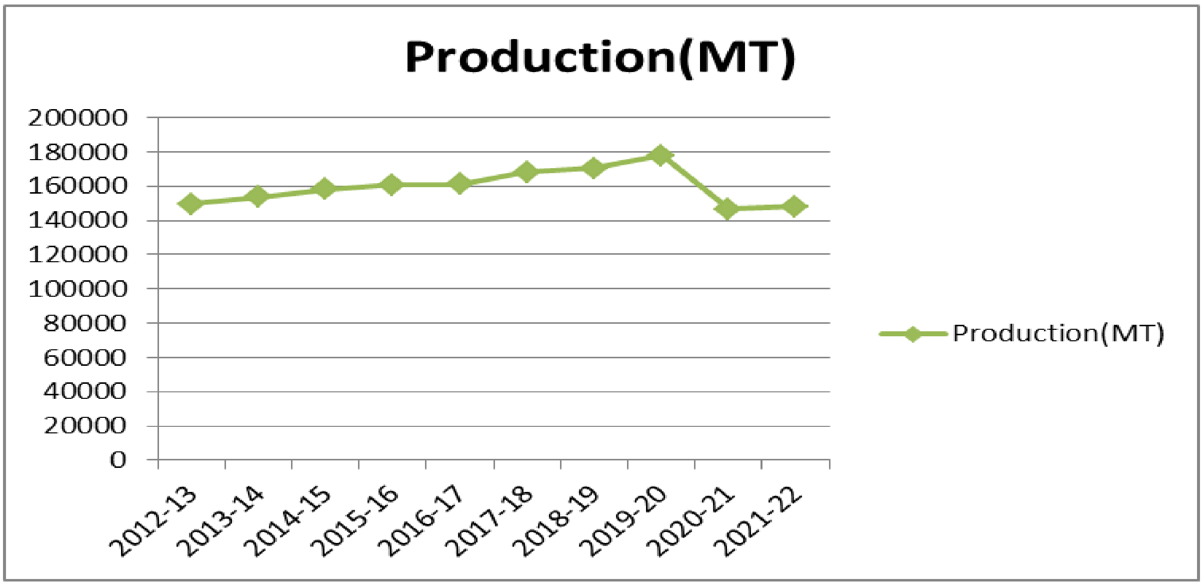
4.3 and 4.4 which demonstrate how the area under cabbage and cabbage production increased steadily until 2020, and simultaneously began to decline in the same year. The area dedicated to cabbage has positive compound growth rate of 0.91 percent since 2012. For the period 2012-2022, the area under cabbage crop has grown at a favorable pace. The overall production has also increased at a compound growth rate of 0.23 percent. Table 4.19 shows the yield per hectare of cabbage crop from 2012 to 2022. With an annual growth rate of -0.67 per cent, the production of cabbage has generally declined during 2021–2022.

Figure 4.3 Area under Cabbage cultivation in hectare (2012-22)



Source: HP DoA Annual Report, 2022

Figure 4.4 Production of Cabbage cultivation in metric tons (2012-22)



Source: HP DoA Annual Report, 2022

4.4.3 Trend of area under Green Pea cultivation, production and productivity since 2012

Table 4.20 Trend of Area, Production and Productivity in Green Pea Crop (2012-22)

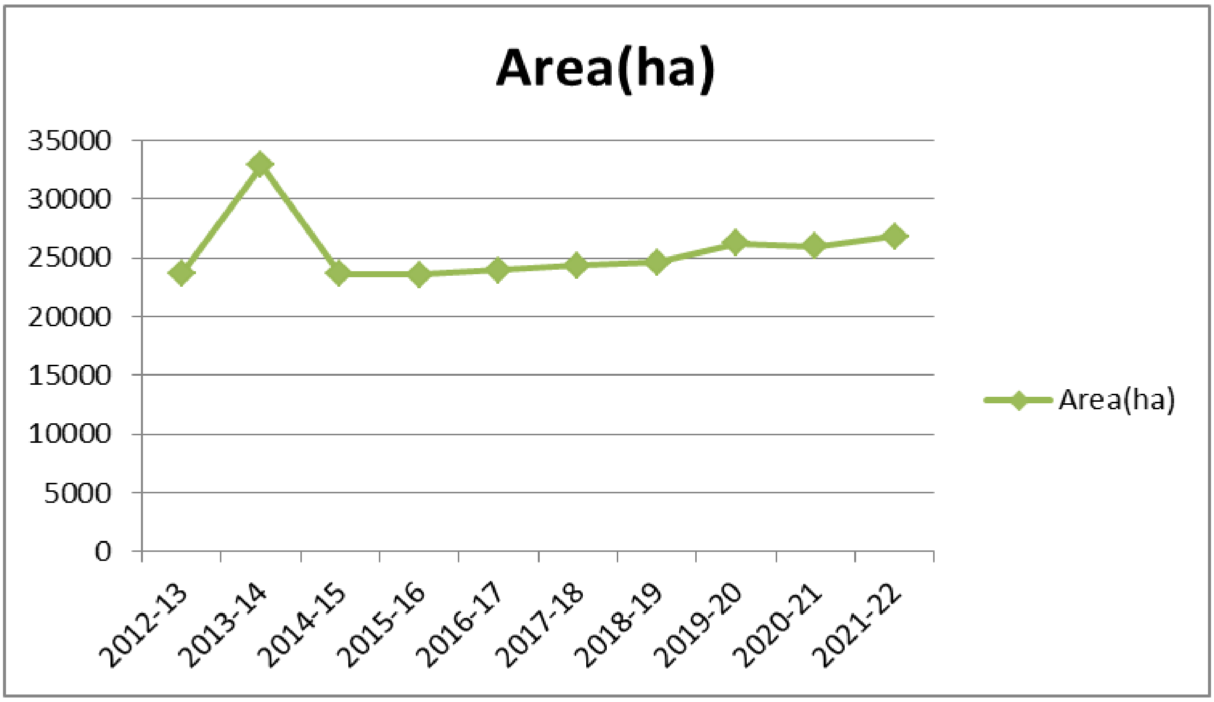
Green Pea			
Year	**Area(ha)**	**Production(MT)**	**Productivity(MT/ha)**
2012-13	23668	280231	11.84
2013-14	32904	271057	11.34
2014-15	23623	277718	11.75
2015-16	23574	276359	11.72
2016-17	23965	291039	12.14
2017-18	24370	294964	12.1
2018-19	24607	296760	12.06
2019-20	26257	329911	12.56
2020-21	25997	328804	12.64
2021-22	26855	338994	12.62
CAGR	**0.1*** **	**2.55*** **	**1.07*** **

Note: *, **, *** means the coefficient is statistically significant at the 10%, 5% and 1% levels

Source: HP DoA Annual Report, 2022

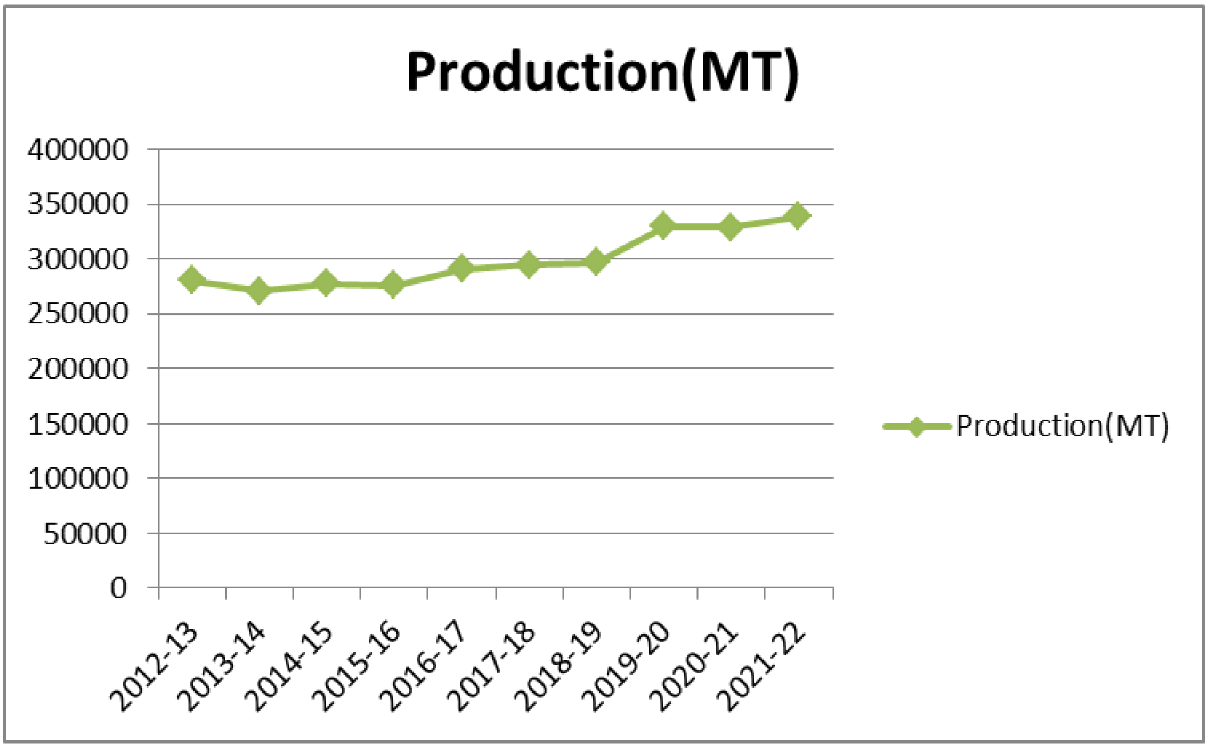
The growth trend and compound annual growth rate of the productivity and green pea production area from 2012 to 2022 are shown in Table 4.20. Green pea production has increased from 280.23 thousand metric tons in 2012–13 to 338.99 thousand metric tons in 2021–22, whereas the area under green pea cultivation has grown from 23.67 thousand hectares in 2012–13 to 26.86 thousand hectares in 2021–22. Figures 4.5 and 4.6 represents the trend line of cultivated area under green pea which showed that area under green pea has largely increased from 2013-14 and declined from 2014-15. However, the data obtained from secondary sources showed no massive change in area under green pea till 2022. Contrarily, production of green pea has slightly increased over the years. The area cultivated to green peas has grown at a compound annual growth rate of 0.1% since 2012. For the period 2012-2022, the area under green pea crop has grown at a favorable pace. The overall production has also increased at a compound growth rate of 2.55 percent. Table 4.20 shows the yield per hectare of green pea crop from 2012 to 2022. The overall yield of green peas increased at a positive rate of 1.07 percent from 2012 to 2022.

Figure 4.5 Area under Green Pea cultivation in hectare (2012-22)



Source: HP DoA Annual Report, 2022

Figure 4.6 Production of Green Pea cultivation in metric tons (2012-22)



Source: HP DoA Annual Report, 2022

4.4.4 Trend of post-harvest losses (in quintals) of Tomato, Cabbage and Green Pea in the study area (2020-2023)

Himachal Pradesh has evolved from cereal-based subsistence agriculture to vegetable-dominated farming for commercial purposes, gaining excellence for its seasonal and off-season vegetable production (Singh and Chauhan, 2017). The state acreage for specific vegetable crops like tomatoes, cabbage, and green peas has grown, with their output increasing steadily and occasionally declining, as shown in Tables 4.4.1, 4.4.2, and 4.4.3. After harvest, produce from agriculture go through a number of processes before they reach consumers such as grading, packing, shipping, storing, processing, and exchange. It involves biological processes like transpiration, respiration, and ripening, these stages can result in large losses in production (Kumar *et al*., 2006 and Singh *et al*., 2013). However, the current study shows the post-harvest losses of tomato, cabbage, and green pea during marketing activities in the research region for the year (2020-2023).

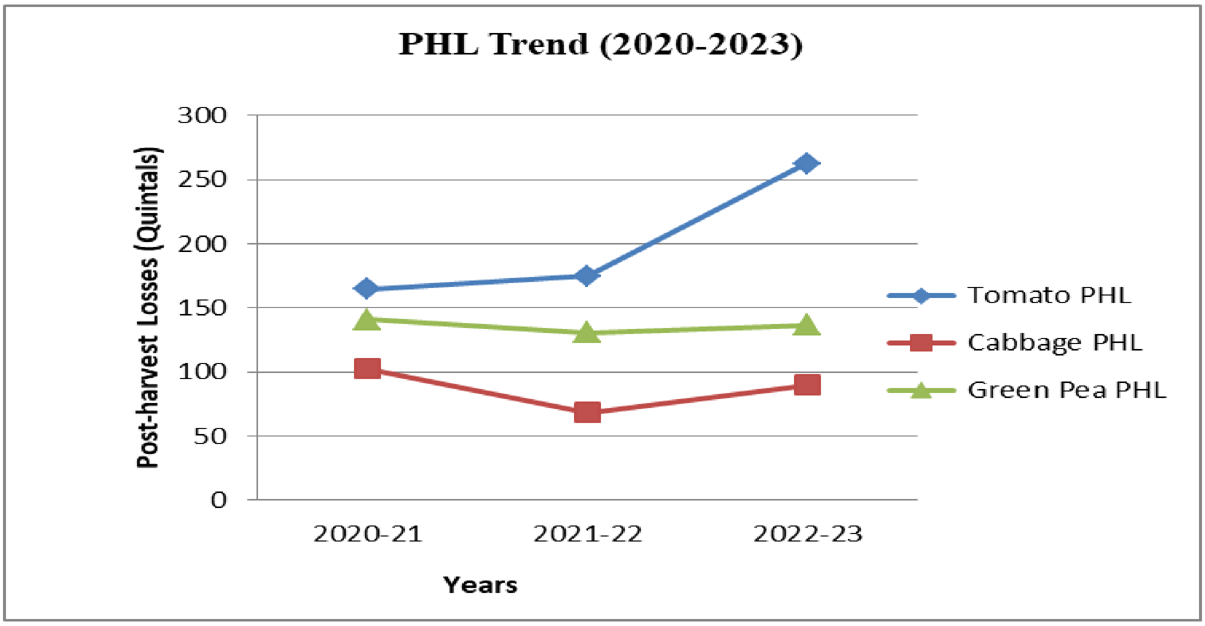
Table 4.21 Post-harvest losses (PHL) (in quintals) of Tomato, Cabbage and Green Pea in the research area during the period 2020-2023

Year / Crop PHL	2020-2021	2021-2022	2022-2023
Tomato PHL (q)	164.79	175.02	262.25
Cabbage PHL (q)	102.14	68.13	89.64
Green Pea PHL (q)	140.76	130.65	136.58

Source: Field Survey, 2022-23

The above table 4.21 presents the post-harvest losses in selected vegetable crops during 2020-2023. Also, Figure 4.7 depicts the trend lines of post-harvest losses (in quintals) of tomato, cabbage, and green peas, revealing that tomato post-harvest loss was determined to be highest, followed by cabbage and green peas over the period of 2020 to 2023. The above table shows that in 2020-2021, tomato crop experienced a total post-harvest loss of 164.79 quintals, followed by green pea at 140.76 quintals and cabbage at 102.14 quintals, while in 2022-23, tomato crop experienced 262.25 quintals post-harvest loss, followed by green pea at 136.58 quintals and cabbage at 89.64 quintals in the research area. The three-year trend data from the research area revealed that post-harvest loss in tomato crops increased over time, whereas post-harvest loss in cabbage and green pea crops decreased in 2021-2022 compared to the previous year and then increased slightly in the following year i.e. 2022-2023.

Figure 4.7 Post-harvest losses trend of Tomato, Cabbage and Green Pea in the research area (2020-2023)



Source: Field Survey, 2022-23

4.5 Existing status of Production and post-harvest losses of selected vegetable crops (2022-23)

Vegetables such as tomatoes, cabbage, and green peas were grown by farmers in the research region. The quantity of selected vegetable production and its losses in the research region were displayed in the tables and figures below.

From the first harvest to the ultimate customer distribution, post-harvest loss happens at different points in the marketing process. The marketable life of vegetables is influenced by variables like temperature, atmospheric composition, storage damage, and pest infection. Deterioration in storage can result in weight loss, physical harm, physiological issues, and moisture loss. Both at the field and market levels, post-harvest loss are determined. Due to the prevalence of diseases and insect pests, farmers have to deal with significant losses when harvesting vegetable crops. Vegetable crops are wasted because of insect pests and diseases that render vegetables unfit for marketing or human consumption. Vegetable crop management stages such as sorting, grading, packing, transporting, storing, and selling can result in post-harvest losses. Post-harvest loss estimation is difficult and less accurate than for durable commodities when it comes to perishable crops like vegetables. Vegetable crop losses vary significantly among markets. The present study estimated postharvest losses for several vegetable crops, including tomato, cabbage, and green pea at different stage of marketing.

4.5.1 Existing status of Tomato crop production in the study Area

Table 4.22 is shown the tomato crop production (in quintals) in study area.

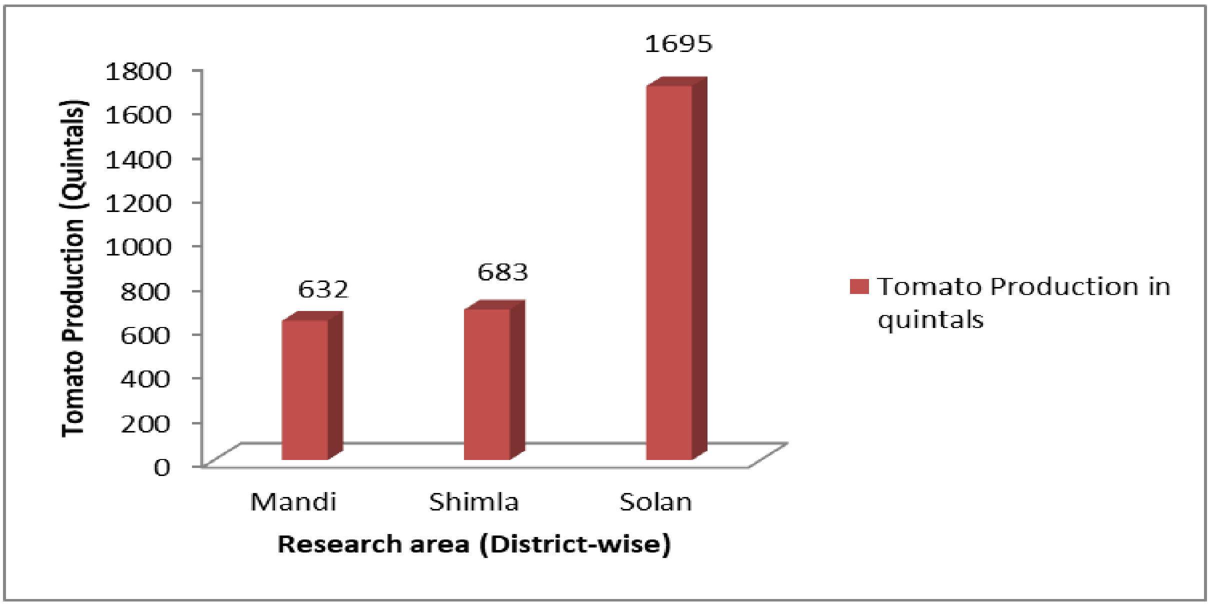
Table 4.22 Production of Tomato Crop (in quintals)

District	Tomato Production (in quintals)
Mandi	632
Shimla	683
Solan	1695
Total	**3010**

Source: Field Survey, 2022-23

Table 4.22 displays data on the total tomato crop production in Mandi, Shimla and Solan district. In the research region, the majority of sampled respondents belonged to small land holdings (i.e., 1-2 ha), as indicated by table 4.15 above. Farmers in the research region produced 3010 quintals of tomato crops in total. However, out of all the districts that were considered, Solan district produced the large quantity of tomatoes—1695 quintals followed by Shimla district came in second with 683 quintals, while Mandi district produced 632 quintals of tomato crop in the research area.

Figure 4.8 Annual crop production status of Tomato in study area



Source: Field Survey, 2022-23

4.5.2 Existing status of post-harvest losses (in quantity term) observed various stages of Tomato crop (2022-2023)

Post-harvest losses of tomato crop at different marketing stages were displayed in Table 4.23. The data acquired from sampled respondents of tomato growers engaged in this particular crop was utilized to calculate post-harvest losses at different phases of the tomato crop.

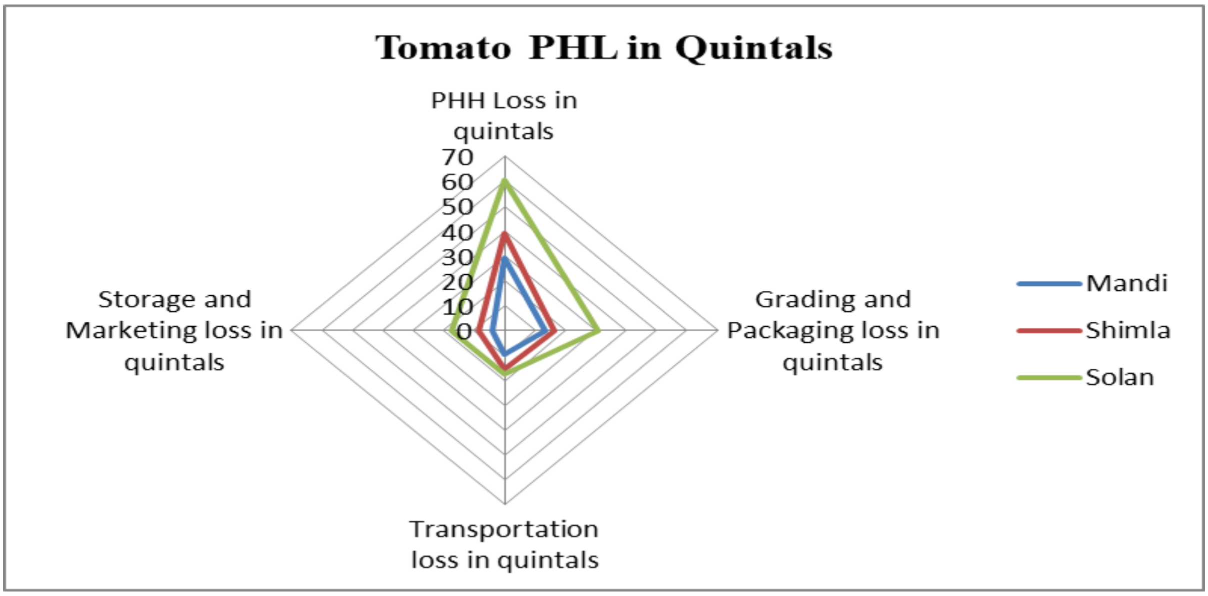
Table 4.23 Post-harvest losses (PHL) in Tomato crop at different stages of marketing (in quintals)

Stages of PHL	Solan	Mandi	Shimla	Overall
Post-harvest handling(q)	60.69	29.37	39.33	129.39
Grading and Packaging(q)	30.85	13.32	16.20	60.37
Transportation(q)	17.63	9.48	15.31	42.42
Storage and Marketing(q)	17.54	4.05	8.48	30.07
Total loss in quintal	**126.71**	**56.22**	**79.32**	**262.25**

Source: Field Survey, 2022-23

Table 4.23 depicted the losses in tomato crop at different stages of marketing such as post-harvest handling, grading, packaging, transportation, storage and marketing. The study found that 60.69 quintals of tomato were lost at the post-harvest handling stage in Solan, 29.37 quintals in Mandi, and 39.33 quintals in Shimla district. The sampled farmers reported in Solan, Mandi and Shimla that 30.85 quintals, 13.32 quintals and 16.20 quintals tomato lost during grading & packaging stage. In Solan, Mandi, and Shimla, respectively, 17.63 quintals, 9.48 quintals, and 15.31 quintals of tomatoes were lost during the transportation stage. During storage and marketing, 17.54 quintals of tomato were lost in Solan, 4.05 quintals in Mandi, and 8.48 quintals in Shimla. The table 4.23 and figure 4.9, 4.10 displayed the total quantity of tomato crop losses in the districts of Solan, Mandi, and Shimla up to 126.71 quintals, or 7.48 per cent, 56.22 or 8.90, and 79.32 or 11.61 respectively. Sharma and Singh (2011), Hazarika (2006) also found that in tomato crop maximum lost estimated in post-harvest handling stage.

Figure 4.9 Post-harvest losses (PHL) in Tomato crop at different stages of marketing (in quintals)



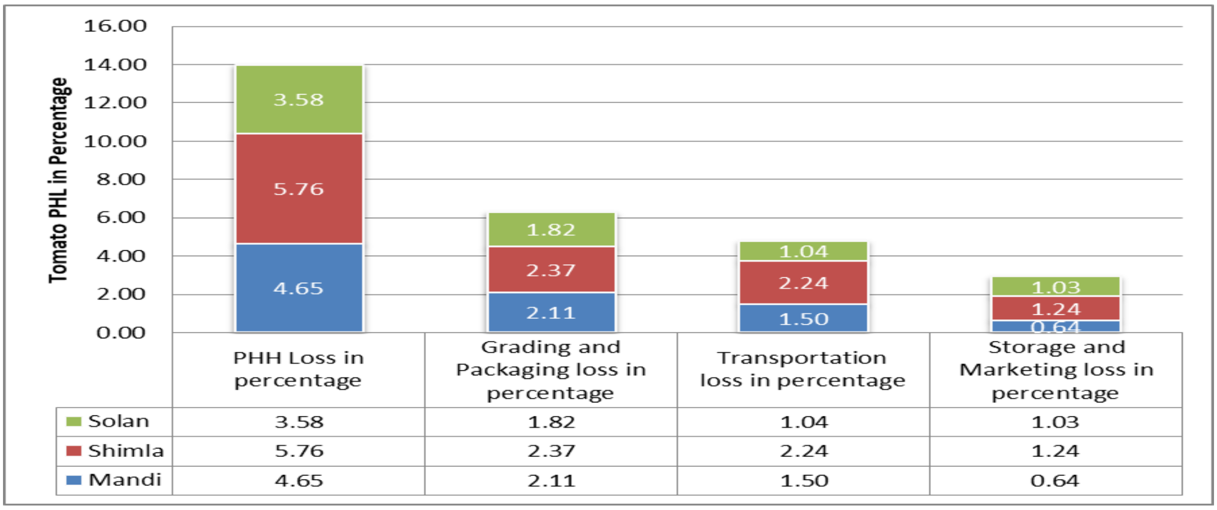
Source: Field Survey, 2022-23

Table 4.24 Post-harvest losses (PHL) in Tomato crop at different stages of marketing (in percentage)

District	PHH Loss (in %)	Grading & Packaging loss (in %)	Transportation loss (in %)	Storage & Marketing loss (in %)	Total loss (in %)
Mandi	4.65	2.11	1.50	0.64	8.90
Shimla	5.76	2.37	2.24	1.24	11.61
Solan	3.58	1.82	1.04	1.03	7.48
Total	**4.30**	**2.01**	**1.41**	**1.00**	**8.71**

Source: Field Survey, 2022-23

Figure 4.10 Post-harvest losses (PHL) in Tomato crop at different stages of marketing (%)



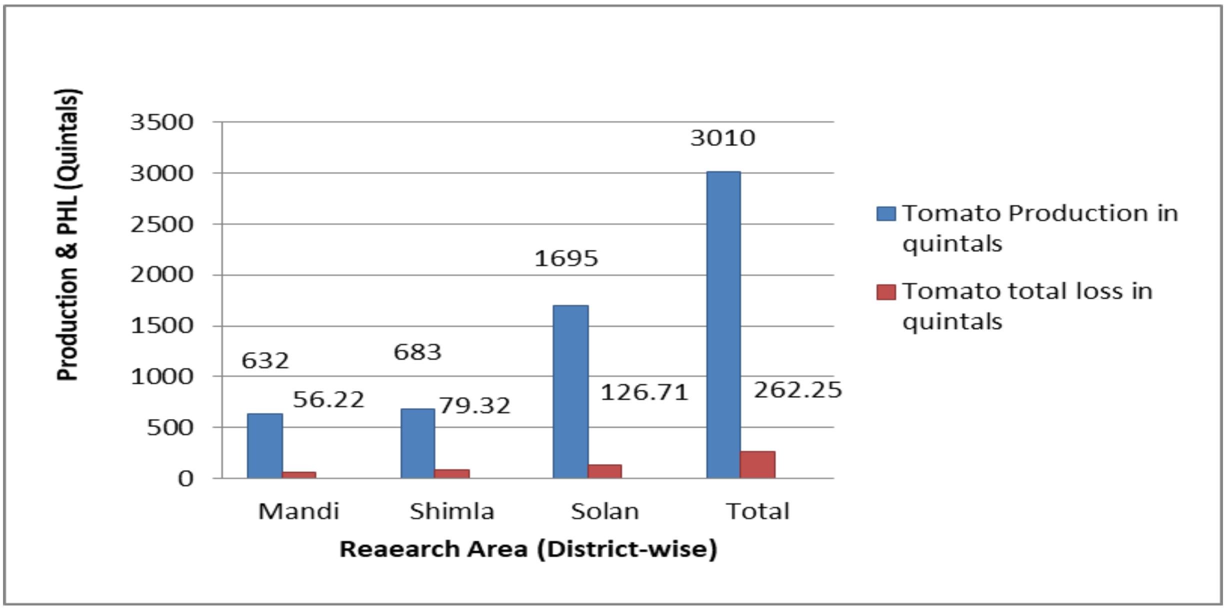
Source: Field Survey, 2022-23

Table 4.25 Tomato crop production and post-harvest losses (PHL) in the study area (in quintals)

District	Tomato Production (in quintals)	Tomato Total loss (in quintals)
Mandi	632	56.22
Shimla	683	79.32
Solan	1695	126.71
Total	**3010**	**262.25**

Source: Field Survey, 2022-23

Figure 4.11 Tomato Production and Post-harvest Losses (in Quintals) in Study Area



Source: Field Survey, 2022-23

According to the above figure 4.11, the sampled farmers produced 3010 quintals of tomatoes during each harvest season, of which 262.25 quintals were lost at various stages of marketing. In the Solan district, 1695 quintals of tomato crop were produced; of which, 56.22 quintals were lost during marketing of produce. Whereas, the Shimla district produced 683 quintals of tomatoes; of which, 79.32 quintals were lost, and the Mandi district produced 632 quintals of tomatoes; of which, 56.22 quintals were lost during various stages of marketing. Overall, the research's findings indicated that 8.71 per cent of the tomatoes in the study region were lost throughout the marketing stage.

4.5.3 Existing status of Cabbage crop production in the study Area

Table 4.26 is shown the cabbage crop production (in quintals) in study area.

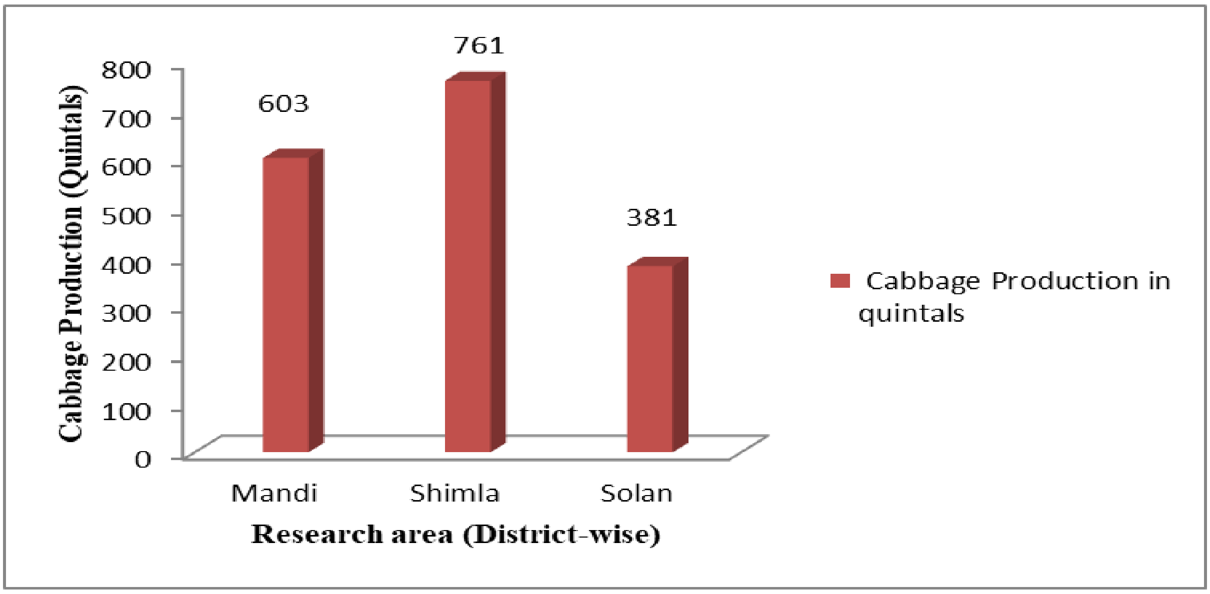
Table 4.26 Production of Cabbage Crop (in quintals)

District	Cabbage Production (in quintals)
Mandi	603
Shimla	761
Solan	381
Total	**1745**

Source: Field Survey, 2022-23

Table 4.26 shows total cabbage production in Mandi, Shimla, and Solan districts. As shown in table 4.15 above, the majority of sampled respondents in the research region belonged to small land holdings (i.e., 1-2 ha). Farmers in the study's area produced a total of 1745 quintals of cabbage. However, Shimla district produced the most cabbage (761 quintal) among all of the districts studied. Mandi district ended in second with 603 quintal of cabbage crops, while Solan district produced 381 quintal.

Figure 4.12 Annual Crop Production status of Cabbage in Study area



Source: Field Survey, 2022-23

4.5.4 Existing status of Post-harvest Losses (PHL) (in quantity term) observed various stages of Cabbage crop

Table 4.27 depicts post-harvest losses for cabbage crops at various marketing stages. Post-harvest losses at various phases of the cabbage crop have been estimated using information acquired from a sample of growers of this specific crop.

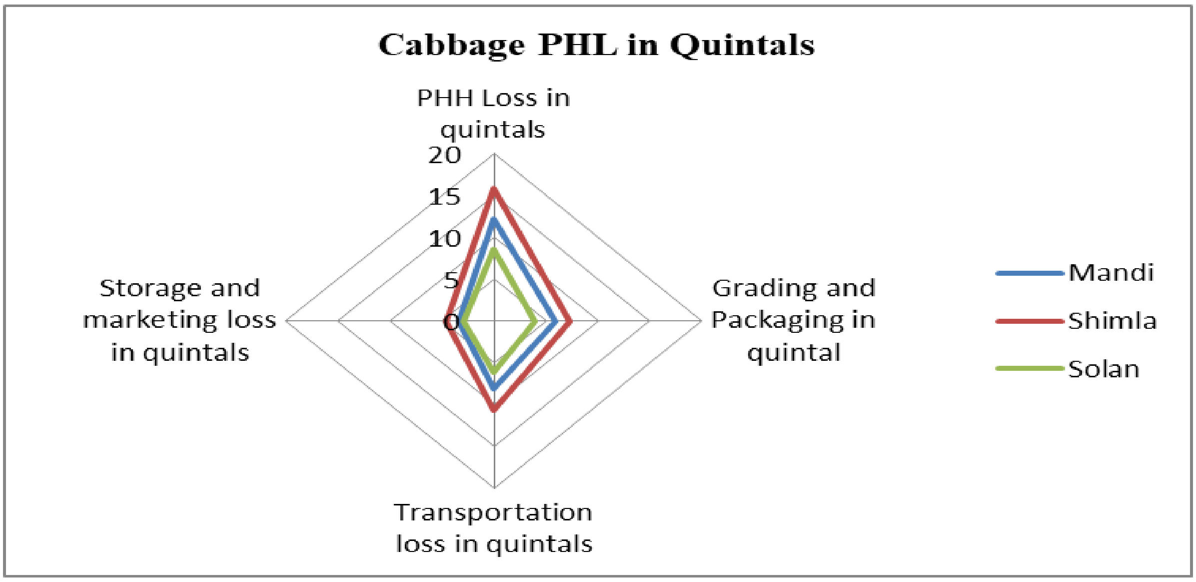
Table 4.27 Post-harvest losses (PHL) in Cabbage crop at different stages of marketing (in quintals)

Stages of PHL	Solan	Mandi	Shimla	Overall
Post-harvest handling(q)	8.63	12.24	15.85	36.72
Grading and Packaging(q)	3.98	5.96	7.31	17.25
Transportation (q)	6.06	8.07	10.73	24.86
Storage and Marketing (q)	2.83	3.41	4.57	10.81
Total loss in quintal	**21.50**	**29.68**	**38.46**	**89.64**

Source: Field Survey, 2022-23

The losses in the cabbage crop were shown in Table 4.27 for several marketing phases, including post-harvest handling, grading, transportation, storage, and marketing. In accordance with the research, 8.63 quintals of cabbage were lost in Solan, 12.24 quintals in Mandi, and 15.85 quintals in the Shimla area during the post-harvest handling stage. As reported by the sampled farmers in the study area, during the grading and packing stage, 3.98 quintals, 5.96 quintals, and 7.31 quintals of cabbage were lost in Solan, Mandi, and Shimla, respectively. On the other hand, during the transit phase, 6.06 quintals, 8.07 quintals, and 10.73 quintals of cabbage were lost in Solan, Mandi and Shimla. During storage and marketing, only 2.83 quintals of cabbage were lost in Solan, 3.41 quintals in Mandi, and 4.57 quintals in Shimla. Total cabbage crop losses in the districts of Solan, Mandi, and Shimla were shown in table 4.27 and figures 4.13, 4.14 up to 21.50 quintals, or 5.64 per cent, 29.68 or 4.92, and 38.46 or 5.05, respectively.

Figure 4.13 Post-harvest losses (PHL) in Cabbage crop at different stages of marketing (in quintals)



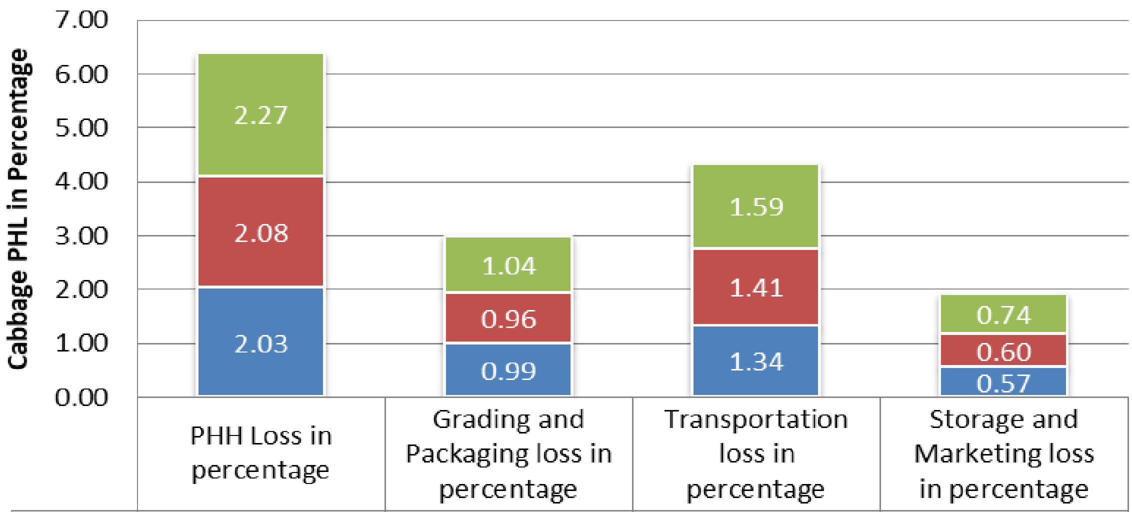
Source: Field Survey, 2022-23

Table 4.28 Post-harvest losses (PHL) in Cabbage crop at different stages of marketing (in percentage)

District	PHH Loss (in %)	Grading & Packaging loss (in %)	Transportation loss (in %)	Storage & Marketing loss (in %)	Total loss (in %)
Mandi	2.03	0.99	1.34	0.57	4.92
Shimla	2.08	0.96	1.41	0.60	5.05
Solan	2.27	1.04	1.59	0.74	5.64
Total	**2.10**	**0.99**	**1.42**	**0.62**	**5.14**

Source: Field Survey, 2022-23

Figure 4.14 Post-harvest losses (PHL) in Cabbage crop at different stages of marketing (%)



	PHH Loss in percentage	Grading and Packaging loss in percentage	Transportation loss in percentage	Storage and Marketing loss in percentage
Solan	2.27	1.04	1.59	0.74
Shimla	2.08	0.96	1.41	0.60
Mandi	2.03	0.99	1.34	0.57

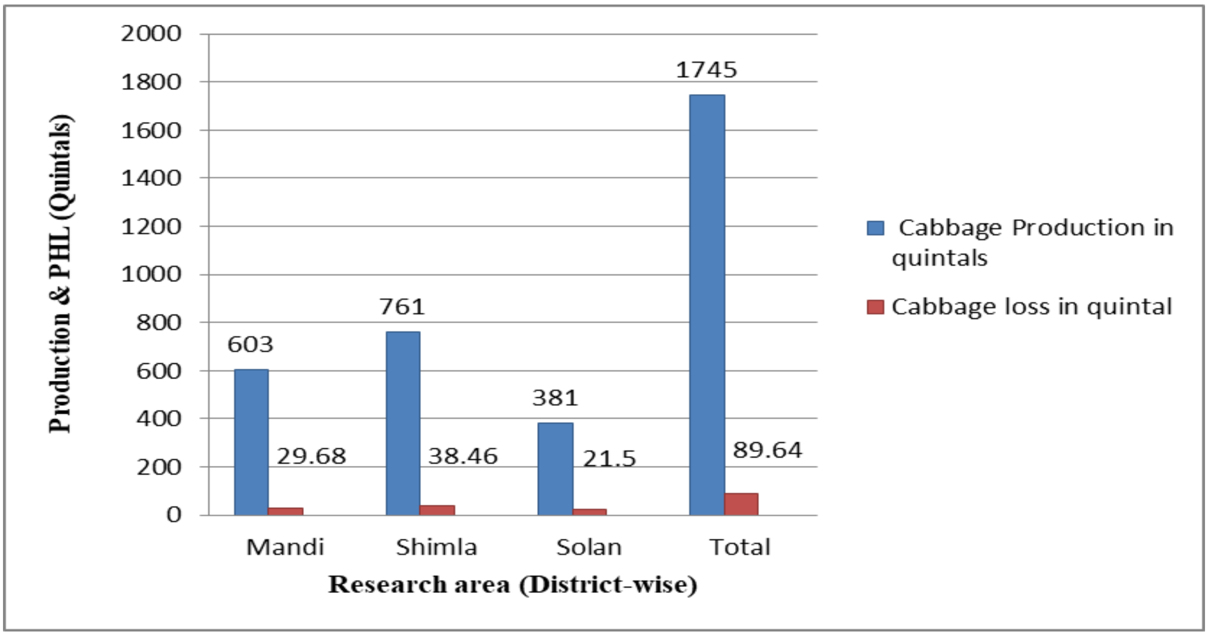
Source: Field Survey, 2022-23

Table 4.29 Cabbage crop production and post-harvest losses (PHL) in the study area (in quintals)

District	Cabbage Production (in quintals)	Cabbage Total loss (in quintals)
Mandi	603	29.68
Shimla	761	38.46
Solan	381	21.5
Total	**1745**	**89.64**

Source: Field Survey, 2022-23

Figure 4.15 Cabbage Total Production and Post- harvest Losses (in Quintals) in Study Area



Source: Field Survey, 2022-23

The above figure 4.15, the sample farmers produced 1745 quintals of cabbage each harvest season, of which 89.64 quintals were lost at various phases of marketing. 381 quintals of cabbage were produced in the Solan district; however, 21.5 quintals were lost throughout the marketing phases. In contrast, the Mandi district produced 603 quintals of cabbage, of which 29.68 quintals were lost throughout various phases of marketing, while the Shimla district produced 761 quintals of cabbage, of which 38.46 quintals were lost. The study's overall conclusions showed that 5.14 percent of the cabbage in the studied area was lost during the marketing phase which is shows in table 4.28.

4.5.5 Existing status of Green Pea crop production in the Study Area

The pea crop production (in quintals) in the study's area is presented in Table 4.30

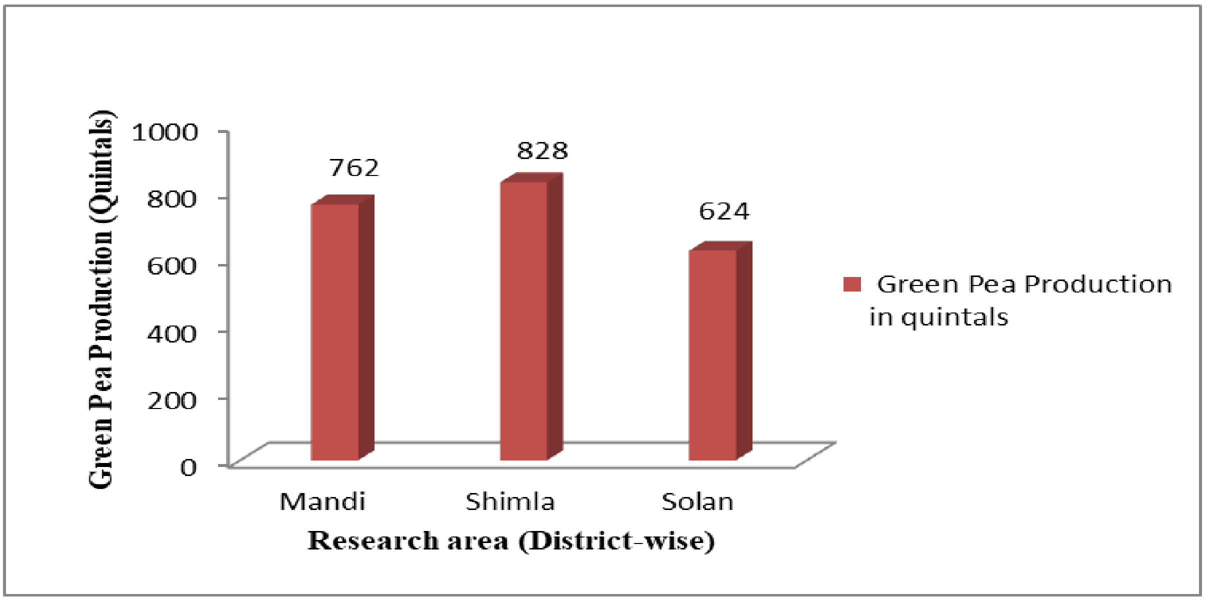
Table 4.30 Production of Green Pea Crop (in quintals)

District	Green Pea Production (in quintals)
Mandi	762
Shimla	828
Solan	624
Total	**2214**

Source: Field Survey, 2022-23

Table 4.30 displays total green pea production in the districts of Mandi, Shimla, and Solan. As shown in table 4.15 above, the majority of sampled respondents in the research region held 1-2 ha of land. Farmers in the study's region harvested 2214 quintals of green peas. However, among the districts examined, Shimla district produced the higher production with 828 quintal green pea. Mandi district ranked second place with 762 quintals production of green pea harvests, while Solan district produced 624 quintal of green pea crop.

Figure 4.16 Annual Crop Production status of Green Pea in Study area



Source: Field Survey, 2022-23

4.5.6 Existing status of Post-harvest Losses (in quantity term) observed various stages of Green Pea crop

Table 4.31 shows post-harvest losses for green pea crops during various marketing phases. Post-harvest losses at various stages of the green pea crop were estimated using the information obtained from sampled respondents who were involved or grow in this specific crop.

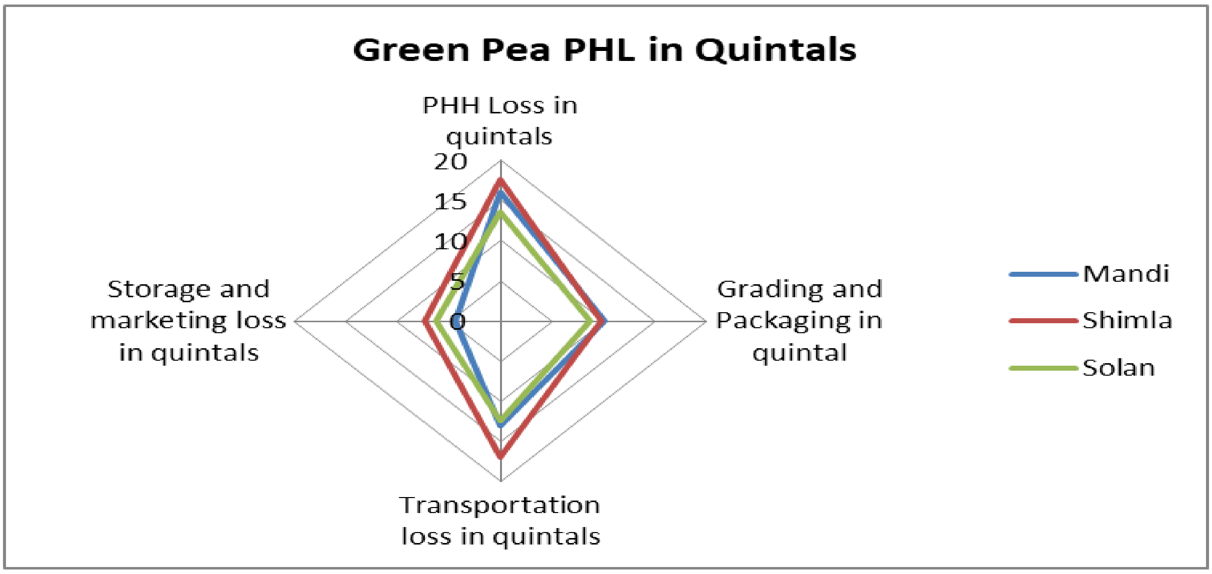
Table 4.31 Post-harvest losses (PHL) in Green Pea crop at different stages of marketing (in quintals)

Stages of PHL	Solan	Mandi	Shimla	Overall
Post-harvest handling	13.59	16.09	17.63	18
Grading and Packaging	8.70	10.14	9.82	8.41
Transportation	12.51	13.07	16.96	17.56
Storage and Marketing	6.21	4.44	7.42	6.10
Total loss in quintal	**41.01**	**43.74**	**51.83**	**50.07**

Source: Field Survey, 2022-23

Table 4.31 displays the losses in the green pea crop during various marketing phases such as post-harvest handling, grading, transportation, storage, and marketing. After harvest, 13.59 quintals of green pea crop were lost in Solan, 16.09 quintals in Mandi, and 17.63 quintals in the Shimla region, as per the findings of the research. The farmers in the sample stated that in Solan, Mandi, and Shimla, respectively, 8.70 quintals, 10.14 quintals, and 9.82 quintals of green pea were lost at the grading and packing stage. However, 12.51 quintals, 13.07 quintals, and 16.96 quintals of green pea crop were lost in the research region during the transportation phase. About 6.21 quintals of the green pea crop were lost in Solan, 4.44 quintals in Mandi, and 7.42 quintals in the Shimla area during storage and exchange. Table 4.27 shows total green pea crop losses in study area, ranging from 41.01 to 51.83 quintals and 5.74 per cent to 6.57 per cent, as shown in figures 4.17 and 4.18.

Figure 4.17 Post-harvest losses (PHL) in Green Pea crop at different stages of marketing (in quintals)



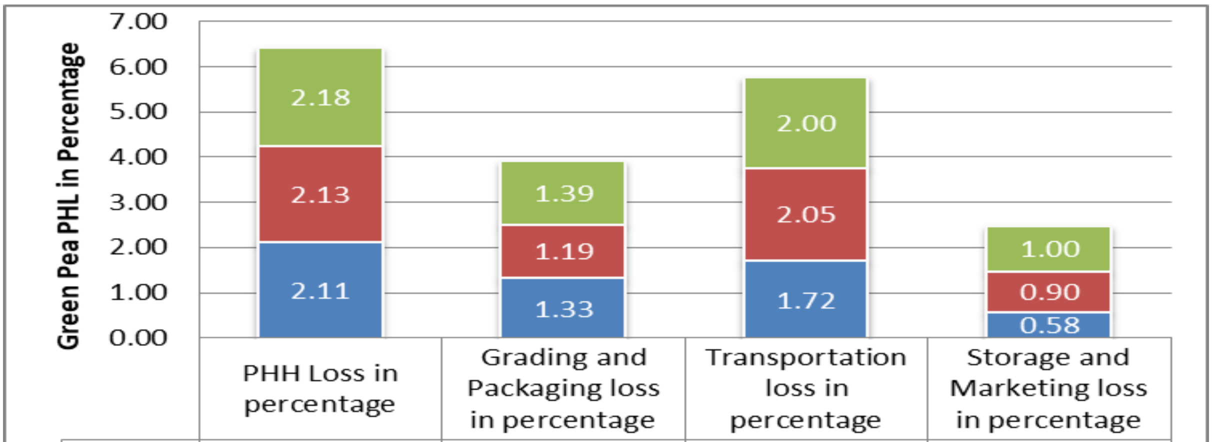
Source: Field Survey, 2022-23

Table 4.32 Post-harvest losses (PHL) in Green pea crop at different stages of marketing (in percentage)

District	PHH Loss (in %)	Grading & Packaging loss (in %)	Transportation loss (in %)	Storage & Marketing loss (in %)	Total loss (in %)
Mandi	2.11	1.33	1.72	0.58	5.74
Shimla	2.13	1.19	2.05	0.90	6.26
Solan	2.18	1.39	2.00	1.00	6.57
Total	**2.13**	**1.29**	**1.92**	**0.82**	**6.17**

Source: Field Survey, 2022-23

Figure 4.18 Post-harvest losses (PHL) in Green Pea crop at different stages of marketing (%)



	PHH Loss in percentage	Grading and Packaging loss in percentage	Transportation loss in percentage	Storage and Marketing loss in percentage
Solan	2.18	1.39	2.00	1.00
Shimla	2.13	1.19	2.05	0.90
Mandi	2.11	1.33	1.72	0.58

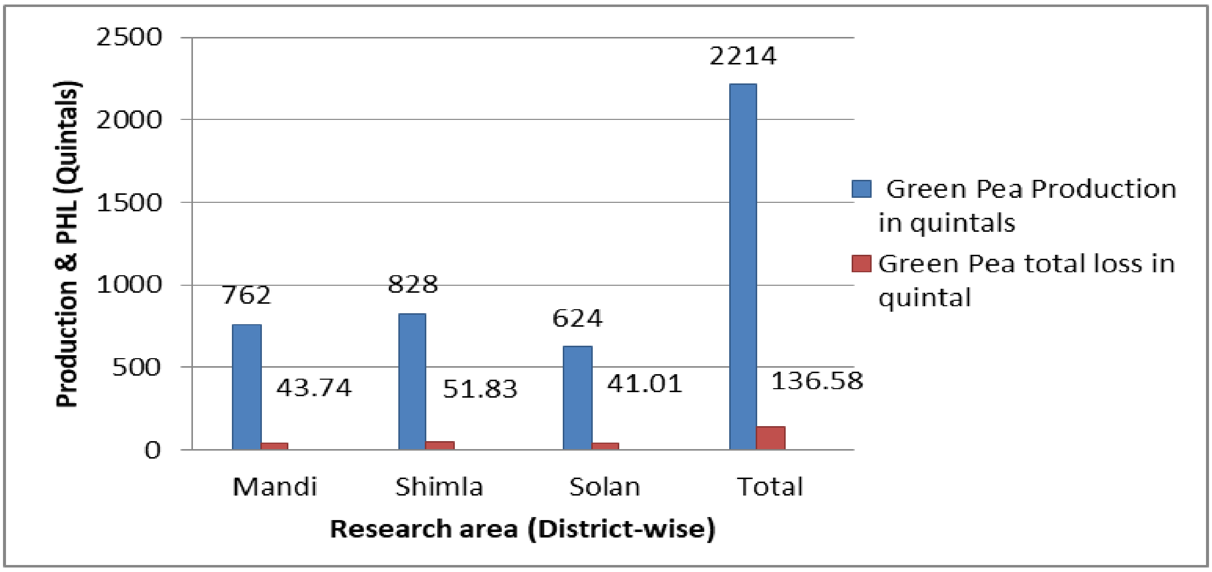
Source: Field Survey, 2022-23

Table 4.33 Green pea crop production and post-harvest losses (PHL) in the study area (in quintals)

District	Green pea Production (in quintals)	Green pea Total loss (in quintals)
Mandi	762	43.74
Shimla	828	51.83
Solan	624	41.01
Total	**2214**	**136.58**

Source: Field Survey, 2022-23

Figure 4.19 Green Pea Total Production and Post-harvest Losses (in Quintals) in Study Area



Source: Field Survey, 2022-23

Figure 4.19 above shows that per harvest season, the sample farmers produced 2214 quintals of green peas, of which 136.58 quintals were lost at various phases of marketing. Out of the 624 quintals of green pea crop produced in the Solan area, 41.01 quintals were lost throughout the marketing phases. In contrast, the Mandi district produced 762 quintals of green peas, of which 43.74 quintals were lost throughout various phases of marketing, while the Shimla district produced 828 quintals of green peas, of which 51.83 quintals were lost. Overall, the research's conclusions showed that throughout the marketing phase, 6.17 per cent of the green peas in the study area were lost.

Section-C: Factor affecting post-harvest losses and management practices adopted by the farmers during marketing of selected vegetable crop in the study area

Fruit and vegetable postharvest losses are affected by factors such as harvesting methods, handling, transit facilities, preservation procedures, and market availability. Modern methods have supported developed nations in minimizing losses, while less automated ways provide a considerable problem for developing nations (Hodges *et al*., 2011). This section of the chapter discusses the factors influencing post-harvest losses and management practices adopted by the farmers in the marketing of tomato, cabbage, and green peas in the research region.

This objective primarily entails figuring out and analyzing the different factors that lead to post-harvest losses throughout the vegetable crop marketing stage. It also examines how farmers' socio-demographic variables may influence these losses throughout marketing of vegetable products. Age, gender, education level, and other social and economic variables may all contribute to post-harvest losses. Rather than focusing on solutions or constraints, the emphasis is on a thorough examination of the factors that cause losses. The scope of this aim focuses on identifying several variables that contribute to post-harvest losses, such as transportation challenges, storage conditions, packaging methods, and market trends.

4.6 Factor affecting Post-harvest Losses during marketing of selected vegetable crop

Vegetable losses begin at the farmers' field and significantly increase during harvesting, causing significant losses for farmers. According to a 2019 Economic Times study, the nation's lack of processing and storage facilities was causing postharvest losses totaling Rs. 2 lakh crore annually. India, the world's second-largest producer of fruits and vegetables, experiences annual spoilage of crores due to insufficient cold storage and refrigerated transport facilities (Kaur and Khurana, 2021). In the present study the major factors which contribute to the post-harvest losses in vegetable crops are the time of harvest, method of harvest, labor used for harvesting, distance to the market, postharvest handling training, and type of packaging, time and place of the market (Singh *et al.*, 2014).

Table 4.34 Quantity of produce lost per harvesting season in selected vegetable crop

Total PHL in Vegetable Crop (%)				
	Low (%)	**Moderate (%)**	**High (%)**	**Total**
Category of Losses	**< 5**	**5-25**	**>25**	
Frequency	126	234	0	360
Percentage	35.0	65.0	0	100.0

Source: Field Survey, 2022-23

Table 4.34 shows the level of post-harvest losses in selected vegetable crops, which can amount to up to 25 per cent of the total yield. According to the data in the table above, the majority of farmers (65%) had significant losses in vegetable crop, ranging from 5 per cent to 25 per cent, while the remaining 35 per cent experienced low loss in the research region.

4.6.1 Factor affecting Post-harvest Losses during marketing of vegetable crop

To study the factors affecting post-harvest losses for marketing of vegetable crop the Ordered Probit Regression Model was used by taking post-harvest losses as the dependent variable (Y) and age, gender, education, farming experience, land holding, occupation, post-harvest training, harvesting time, method, packaging, distance to the market, labor used for harvesting, time and place for sale as the independent variables.

The degree of multicollinearity was assessed using STATA version 18 software package. Table 4.35 displays the results, which indicate that there was no issue with multicollinearity among the explanatory variables included in any of the regression models because all of the tolerance factors were near to one and the variance inflation factors were below the threshold value of 10 (Gujarati and Porter, 2009). Table 4.35 was also reported the mean VIFs of 1.16 for Tomato, 2.35 for cabbage and 0.77 for green pea. For this purpose, the regression model included all of the suggested explanatory factors. Heteroscedasticity was also addressed using robust standard errors.

Table 4.35 Testing tools for determining the level of multicollinearity

Variable	Tomato		Cabbage		Green Pea	
	VIF	Tolerance (1/VIF)	VIF	Tolerance (1/VIF)	VIF	Tolerance (1/VIF)
Age of the respondents	1.18	0.85	1.17	0.86	1.17	0.85
Education Qualification	1.22	0.82	1.18	0.85	1.20	0.83
Method of harvesting	1.06	0.94	1.06	0.95	1.11	0.91
Family type	1.11	0.90	1.11	0.91	1.10	0.91
Land holding capacity	1.05	0.96	1.02	0.98	1.04	0.97
Farming experience	1.13	0.89	1.10	0.91	1.10	0.91
PHH training	1.11	0.90	1.15	0.87	1.79	0.56
Time of Harvest	1.37	0.73	1.13	0.89	1.31	0.76
Distance to the market	1.21	0.83	9.48	0.11	1.78	0.56
Type of packaging	1.19	0.84	1.18	0.85	1.24	0.81
Time of sale	1.30	0.77	1.34	0.75	1.35	0.74
Storage facility	1.13	0.88	1.21	0.83	1.92	0.52
Labour used for harvesting	1.15	0.87	9.76	0.10	1.88	0.53
Access to market information	1.06	0.95	1.06	0.95	1.06	0.94
Mean VIF	**1.16**		**2.35**		**0.77**	

Source: Field Survey, 2022-23

The results of regression estimates shows relationship of the selected variables with the post-harvest losses on selected vegetable crops in the study area for the year 2022-23 are represented in Table 4.36, 4.37 and 4.38. By using ordered probit estimates, those variables or factors that significantly affect the tomato post-harvest losses include age of the respondents, farm size of the respondents, farming experience, education qualification, post-harvest handling training, time of harvest, distance to the market, time and of sale, type of packaging, method of harvest, storage facility, access to the market information were indicated in Table 4.36. Factors that significantly affect the cabbage post-harvest losses include family type, farming experience, distance to the market, and type of packaging, method of harvesting, time of sale etc. as presented in Table 4.37. On the other hand, factors that significantly affected the green pea post-harvest losses include age, education, family type, distance to the market, type of packaging and labor used for harvesting etc. as represented in Table 4.38.

Pseudo R- squared measures the explanatory strength of the components. The tomato crop had a pseudo R-squared of 0.34, the cabbage crop of 0.39, and the green pea crop of 0.29. This indicates that the exploratory variables in the model explained 34% of the post-harvest losses in tomatoes, 39% of the losses in cabbage, and 29% of the losses in green peas. The regression model appeared that it performed well in terms of fulfilling the previous estimations regarding the connection between the dependent and the explanatory factors. The actual amount of variation or likelihoods in the coefficients was not shown by the estimated parameters of the ordered probit model; instead, they simply revealed the direction of the impact of the explanatory variables on the dependent variable. Therefore, the expected change in likelihood of a particular amount of impact on decision making is measured by the marginal effects of the ordered probit model outcome. This relates to an independent variable's change in units shown in Table 4.36, 4.37 and 4.38.

4.6.1.1 Age of the respondent

In this study, the age of the individuals who participated had a negative but statistically insignificant connection with post-harvest losses for tomato, cabbage, and green peas. Based to the findings, there was no linear correlation between respondents' ages and the level of post-harvest losses in selected vegetable crops. The result showed that with the increase of respondent age there will be the chance of decreasing post-harvest losses. Yeshiwas and Tadele (2021) reported that age does not significantly affect the post-harvest losses of vegetable crops. In Contrast, Asayehegn *et al.* (2011) reported that age was an important factor that affects the farm related decisions. Shee *et al.*, 2019 concluded that the older the respondent, the higher the possibility that they will fall into the higher perceived loss category, with age being a significantly favorable factor.

4.6.1.2 Education of the respondent

In the research region, education level reported to have negative but statistically insignificant relationship with post-harvest losses of tomato, cabbage and green pea. The finding suggests that higher education of the farmers, reduce the post-harvest losses of selected vegetable crops. Another authors study also indicated that that farmers with greater education have less extensive post-harvest losses than farmers with lower education (Shee *et al.*, 2019; Mebratie *et al.*, 2015); Kikulwe *et al.*, 2018), Garikai (2014) also reported the similar results. Whereas, Babalola *et al.* (2010) also found that farmers with low literacy levels had large post-harvest losses. They claimed that illiteracy might be a factor that causes major post-harvest losses in tomato production since only farmers with higher education can recognize and apply the majority of available post-harvest technologies for the reduction of post-harvest losses in the selected vegetable crops. Education can help with postharvest technology awareness and interaction, especially for fruit merchants (Mashau *et al*., 2012).

4.6.1.3 Methods use for harvesting

A positive but statistically insignificant relationship was observed between methods used for the harvesting of selected vegetable crops and post-harvest losses of tomato, cabbage and green pea crop in the study area. The result implies that there is a correlation between the methods of harvesting and post-harvest losses of the selected vegetable crops but not statistically significant. The study's findings indicated that harvesting a certain vegetable crop using mechanical or unconventional methods might result in higher post-harvest losses of that crop.

4.6.1.4 Family size of the respondents

Post-harvest losses are significantly influenced by a demographic component called family size. The study found a positive but statistically significant correlation between the sample respondent's family size and post-harvest losses of green peas and cabbage crop (significant at 10% level). The family size of the investigated framers and tomato post-harvest losses were shown to be positively correlated, but statistically not significantly. Aidoo *et al*., 2014 reported that significantly the amount of post-harvest losses encountered was found to be negatively correlated with family size. Due to greater family effort during tomato harvesting, farmers with bigger households had reduced postharvest losses, resulting in quicker and more effective operations.

Table 4.36 Ordered probit regression results for Tomato crop

Variable	Ordered Probit Regression			Marginal effect outcome 1 Low Losses (<5%)			Marginal effect outcome 2 Moderate Losses (5-25%)		
	Coeff.	Robust SE	Sig.	Coeff.	Robust SE	Sig.	Coeff.	Robust SE	Sig.
Age of the respondents	-0.02	0.12	0.88	0.004	0.03	0.46	-0.004	0.03	0.46
Education Qualification	-0.02	0.10	0.86	0.004	0.02	0.86	-0.004	0.02	0.86
Family size	0.27	0.21	0.18	-0.07	0.05	0.18	0.07	0.05	0.18
Land holding capacity	-0.01	0.12	0.97	0.001	0.03	0.97	-0.001	0.03	0.97
Experience status	-0.03	0.09	0.77	0.01	0.02	0.76	-0.01	0.02	0.76
Distance to the market	**1.23*****	0.19	0.00	**-0.29*****	0.04	0.00	**0.29*****	0.04	0.00
Time of Harvest	**0.30***	0.18	0.09	**-0.07***	0.04	0.08	**0.07***	0.04	0.08
PHH training	**-0.63*****	0.17	0.00	**0.15*****	0.04	0.00	**-0.15*****	0.04	0.00
Type of packaging	**0.69***	0.36	0.06	**-0.17***	0.09	0.06	**0.17***	0.09	0.06
Time of sale	**0.82*****	0.17	0.00	**-0.20*****	0.04	0.00	**0.20*****	0.04	0.00
Storage facility	**1.26*****	0.20	0.00	**-0.30*****	0.04	0.00	**0.30*****	0.04	0.00
Labour used for harvesting	0.27	0.36	0.45	-0.07	0.09	0.45	0.07	0.09	0.45
Access to market information	-0.14	0.19	0.45	0.03	0.05	0.46	-0.03	0.05	0.46
Method of harvesting	0.12	0.07	0.11	-0.03	0.02	0.11	0.03	0.02	0.11
Wald Chi^2 (14)	**123.26**								
Pseudo R^2	**0.3419**								
Log-likelihood	**-153.37975**								
N	**360**								

Note: *, **, *** means the coefficient is statistically significant at the 10%, 5% and 1% levels

Source: Field Survey, 2022-23

Table 4.37 Ordered probit regression results for Cabbage crop

Variable	Ordered Probit Regression			Marginal effect outcome 1 Low Losses (<5%)			Marginal effect outcome 2 Moderate Losses (5-25%)		
	Coeff.	Robust SE	Sig.	Coeff.	Robust SE	Sig.	Coeff.	Robust SE	Sig.
Age of the respondents	-0.01	0.13	0.92	0.00	0.03	0.92	-0.00	0.03	0.92
Education Qualification	-0.08	0.10	0.45	0.02	0.02	0.44	-0.02	0.02	0.44
Family size	**0.38***	0.20	0.06	**-0.08***	0.04	0.06	**0.08***	0.04	0.06
Land holding capacity	0.01	0.11	0.95	-0.00	0.02	0.95	0.00	0.02	0.95
Experience status	**-0.19****	0.09	0.03	**0.04****	0.02	0.03	**-0.04****	0.02	0.03
Distance to the market	**0.41****	0.18	0.02	**-0.09****	0.04	0.02	**0.09****	0.04	0.02
Time of Harvest	0.20	0.16	0.22	-0.04	0.04	0.21	0.04	0.04	0.21
PHH training	**-1.38*****	0.48	0.00	**0.30*****	0.10	0.00	**-0.30*****	0.10	0.00
Type of packaging	**0.92****	0.33	0.01	**-0.20****	0.07	0.01	**0.20****	0.07	0.01
Time of sale	**0.50****	0.21	0.02	**-0.11****	0.04	0.01	**0.11****	0.04	0.01
Storage facility	**0.35****	0.18	0.05	**-0.08****	0.04	0.04	**0.08****	0.04	0.04
Labour used for harvesting	0.16	0.48	0.74	-0.04	0.11	0.74	0.04	0.11	0.74
Access to market information	0.02	0.20	0.92	-0.00	0.04	0.92	0.00	0.04	0.92
Method of harvesting	0.09	0.08	0.21	-0.02	0.02	0.20	0.02	0.02	0.20
Wald Chi^2 (14)	**147.40**								
Pseudo R^2	**0.3936**								
Log-likelihood	**-141.35096**								
N	**360**								

Note: *, **, *** means the coefficient is statistically significant at the 10%, 5% and 1% levels

Source: Field Survey, 2022-23

Table 4.38 Ordered probit regression results for Green Pea crop

Variable	Ordered Probit Regression			Marginal effect outcome 1 Low Losses (<5%)			Marginal effect outcome 2 Moderate Losses (5-25%)		
	Coeff.	Robust Std. Err	Sig.	Coeff.	Robust Std. Err	Sig.	Coeff.	Robust Std. Err	Sig.
Age of the respondents	-0.02	0.12	0.85	0.01	0.03	0.85	-0.01	0.03	0.85
Education Qualification	-0.00	0.10	0.99	0.00	0.03	0.99	0.00	0.03	0.99
Family size	**0.36***	0.19	0.06	**-0.10***	0.05	0.06	**0.10***	0.05	0.06
Land holding capacity	-0.10	0.11	0.33	0.03	0.03	0.33	-0.03	0.03	0.33
Experience status	-0.10	0.09	0.28	0.03	0.02	0.28	-0.03	0.02	0.28
PHH training	-0.16	0.24	0.51	0.04	0.06	0.51	-0.04	0.06	0.51
Time of Harvest	0.26	0.21	0.21	-0.07	0.06	0.21	0.07	0.06	0.21
Distance to the market	**1.15*****	0.20	0.00	**-0.30*****	0.04	0.00	**0.30*****	0.04	0.00
Type of packaging	**0.64*****	0.18	0.00	**-0.17*****	0.04	0.00	**0.17*****	0.04	0.00
Time of sale	0.07	0.31	0.82	-0.02	0.08	0.82	0.02	0.08	0.82
Storage facility	0.01	0.21	0.95	0.00	0.06	0.95	0.00	0.06	0.95
Labour used for harvesting	**0.80*****	0.26	0.00	**-0.21*****	0.06	0.00	**0.21*****	0.06	0.00
Access to market information	-0.12	0.19	0.54	0.03	0.05	0.54	-0.03	0.05	0.54
Method of harvesting	0.03	0.07	0.69	-0.01	0.02	0.69	0.01	0.02	0.69
Wald Chi^2 (14)	**88.76**								
Pseudo R^2	**0.2878**								
Log-likelihood	**-165.98941**								
N	**360**								

Note: *, **, *** means the coefficient is statistically significant at the 10%, 5% and 1% levels

Source: Field Survey, 2022-23

4.6.1.5 Land holding capacity of the farmers

For the tomato and green pea crops, there was a negative but statistically insignificant correlation discovered between farm size and post-harvest losses. This suggests that post-harvest losses will decrease with an increase in tomato and green pea farm size. Nonetheless, a positive and statistically insignificant correlation was found between the sampled respondent's farm size and the post-harvest losses of the cabbage crop in the study area. This suggested that the chance of post-harvest losses tends to grow with farm size when it comes to cabbage. Garikai (2014) found a similar outcome with the cabbage crop.

Babalola *et al.*, 2010 and Aidoo *et al.,* 2014 reported that farmers will face more challenges with storage and transportation as their farm's size grows. In cases where these facilities are inadequate, producers risk severe losses. The more growing area, the greater quantity produced and the likelihood of losses from improper handling and storage. However, Martey *et al.* (2012) contended that farm size may have additional advantages for market participation through enabling farmers to overcome financial markets and produce surpluses, which lowers postharvest losses. On the other hand, Garikai (2014) resulted from the study that reduction in farm size or land dedicated to tomatoes has the overall impact of lowering tomato postharvest loss rather than increasing farm size or land dedicated to tomatoes.

4.6.1.6 Farming Experience of the farmers

The results indicated a negative but statistically insignificant correlation between the selected farmers' farming experience and post-harvest losses of tomatoes and green peas. Conversely, post-harvest losses in cabbage were negatively and statistically significantly correlated with agricultural experience (significant at 5% level). These findings suggested that as farmers' levels of experience increased, post-harvest losses declined. Experienced farmers exhibit signs of having embraced postharvest management technologies and exhibiting a deep understanding of them. Garikai (2014) has seen similar results, indicating that more experienced farmers incur lower post-harvest losses in their cabbage crops. Additionally, Garikai came to the conclusion that age and agricultural experience were associated, with elderly farmers holding greater knowledge and using it to reduce post-harvest losses. Similar results were also seen by Babalola et al. (2010), who highlighted towards how post-harvest losses might decrease as farmer experience increased. The conclusion of marginal effect indicates that one unit increase in farming experience of farmers significantly reduced the post-harvest losses in cabbage crop.

4.6.1.7 Post-harvest handling training

Training in post-harvest handling is necessary to assess how expert advice affects post-harvest losses. For both the tomato and the cabbage crop, post-harvest losses showed a statistically significant negative correlation with post-harvest handling training (significant at 1% level for tomato and cabbage respectively). This suggests that training in post-harvest handling lowers the crop losses of tomatoes and cabbage after harvest. On the other hand, a negative and statistically insignificant connection was found between post-harvest losses in the green pea crop and post-harvest handling training. This indicates that post-harvest losses were less frequent among farmers who participated in post-harvest management training. Post-harvest losses were reduced by farmers who were more inclined to handle produce carefully after attending post-harvest handling training. The same outcomes were also reported by Garikai (2014) and Cossam *et al*., 2023. Akpalu (2013) concluded that farmers in

South Africa evaluate the usefulness of extension services in relation to obtaining technological knowledge and guidance for the production of crops. Shee *et al.*, 2019 also reported that Farmers that underwent post-harvest management training experience lower losses during harvest and storage. Overall, post-harvest losses of tomatoes and cabbage are significantly reduced with post-harvest handling instruction. For farmers who are suffering large losses, post-harvest handling training participation significantly lowers post-harvest losses for tomatoes and cabbage.

4.6.1.8 Time of harvest

One of the most crucial factors in determining post-harvest losses in vegetable crops is the time of harvest (Awan *et al*., 2012). Tomato post-harvest losses are positively, but statistically significantly, correlated with the timing of harvest (significant at 10% level). However, post-harvest losses of green peas and cabbage showed a positive and statistically insignificant connection. Harvesting of tomatoes, cabbage, and green peas should take place early in the morning due to their physiological composition. Tomatoes' delicate gloss cuticle and cabbage's leafy texture both cause water loss; with cabbage losing less water because of its smaller surface area (Garikai, 2014). The study's findings suggest that delaying the time frame for harvesting can possibly enhance post-harvest losses. Genova *et al*. (2006) and Kereth *et al*. (2013) came to the similar conclusion in their studies: harvesting ought to be done in the morning. Vegetables can be adversely affected by high temperatures during afternoon harvesting because they accelerate biological processes like respiration and metabolism (Mashau *et al*., 2012). Harvesting fruits and vegetables should be done either early in the morning or late at night to prevent mechanical damage including bruising, scratches, and punctures (Muhammad *et al*., 2012). The marginal effect results shows that with one-unit increase in tomato time harvest will also significantly increase the tomato post-harvest losses.

4.6.1.9 Distance to the market

The study discovered a positive, though statistically significant, correlation between post-harvest losses of tomatoes, cabbage, and green peas and the distance between agricultural fields and the market (significant at 1% for tomato and green pea; at 5% for cabbage respectively). The study's conclusion suggests that post-harvest losses in the chosen vegetable crops increase with the distance between farms and the market. Similar results were concluded by Babalola *et al.* (2010) and Garikai (2014) that tomato postharvest losses were positively and substantially correlated with the distance between the farm and the market. The greater the time it takes for the crop to be transported from the farm to the market, the higher the post-harvest losses because of the excessive heat and mechanical damage sustained during movement (Kader, 2005). Postharvest losses have been recorded to reach 50% in Kenya and Tanzania, dependent upon the type of vegetable, meteorological circumstances, and distance from markets (Lenne and Ward, 2010). According to the study, a short distance of 10-20 kilometers is characterized by rough dust roads, which cause mechanical damage due to vibration. The lack of chilling facilities and transportation systems contributes to post-harvest losses. The accumulation of unorganized packed crops in open vehicles during transportation may raise temperatures and hasten mechanical damage. Farmers of tomatoes, cabbage, and green peas who are already suffering large losses will find that even a marginal increase in the distance to the market significantly increases their postharvest losses.

4.6.1.10 Type of packaging

In order to reduce postharvest loss, packaging used in postharvest handling is essential. To prevent excessive movement or vibration, the produce should be properly packaged and stacked during transportation. The study revealed that type of packaging used for marketing of crops had positive though statistically significant relationship with post-harvest losses of tomato, cabbage and green pea (significant at 10% for tomato, 5% for cabbage and 1% for green pea respectively). The result indicates that type of packaging used for vegetable crops can impact post-harvest losses. Effective packaging can controls the factors such as moisture, temperature and physical damage which contributing to overall reduction in post-harvest losses in selected vegetable crops. So it is important to select appropriate packaging techniques to enhance the shelf-life of harvested vegetable and reduce the post-harvest losses in vegetables. In contrast, Garikai (2014) argued negative but statistically significant relationship between packaging used and post-harvest losses of tomato and cabbage crop. It has been demonstrated that using plastic crates for fresh produce harvesting, packaging, transporting, and storing reduces damage and postharvest losses (Kitinoja, 2010). Retainable plastic crates (RPCs) were highlighted as an innovative solution for packaging ideal for poor nations in a study presented by the Save Food Interpack 2011 conference. RPCs can resist harsh road transport, prevent damage, and be reused numerous times (FAO, 2011).

4.6.1.11 Time of sale

Due to the perishable nature of tomatoes and cabbage, there was a positive but statistically significant relationship found between the time for selling vegetable crops and post-harvest losses of tomatoes and cabbage (significant at 1% level for tomatoes and 5% for cabbage). This relationship suggested that the chance of post-harvest losses of tomatoes and cabbage increased as the time for selling increased. Conversely, there was a positive, but statistically insignificant, correlation between the timing of green pea marketing and the crop's post-harvest losses. The outcome suggests that there may be more possibilities for environmental conditions, pests, diseases, etc. to have a detrimental influence on the amount and quality of harvested product if there was a longer period of time between harvesting and selling. The result of marginal effect shows that a unit increase in time for marketing of tomato and cabbage would significantly increase the post-harvest losses of selected vegetable crop.

4.6.1.12 Labour used for harvesting

A positive and statistically insignificant relationship was found between the labour used for harvesting and post-harvest losses of tomato and cabbage. However, a positive and statistically significant relationship was observed between labour used for harvesting and post-harvest losses of green pea crop (significant at 1% level for green peas). The study revealed that as the amount of labour dedicated to harvesting increase or when more labour was employed for harvesting, there was an observable increase in the amount of produce lost during post-harvest stage due to inefficient harvesting practices, improper handling of produce during transportation which lead to mechanical damage to the crop. The study found a significant positive correlation between the amount of labor used for harvesting green pea crops and post-harvest losses, suggesting that an increase in labor usage leads to higher post-harvest losses. The result of marginal effect indicated that one unit increase in labour used for harvesting will significantly increase the post-harvest losses of green pea crop.

4.6.1.13 Storage facility

In the study analysis, there was a positive and statistically significant relationship between storage facilities and tomato and cabbage post-harvest losses (significant at 1% level for tomato and at 5% level for cabbage). A positive and statistically insignificant relationship was observed between storage facility and post-harvest losses of green pea crop. These findings indicate that preserving harvested product longer before transporting it to market increases the risk of postharvest losses. Garikai (2014) also reported similar results for tomato crop. When vegetable crops were fresh, fruits and vegetables have high water content. The quality of the produce declines when the produce gets shriveled and drooping as it loses water. These actions lead them to deteriorate during transportation and storage, which happens more quickly in hot and muggy environments. For this reason, short storage periods are necessary. In contrast, Garikai (2014) found negative and insignificant relationship among storage and post-harvest losses in cabbage crop because cabbage had longer shelf life as compared to the tomatoes. Yahia (2006) contended that the degree of texture, flavor, fragrance, rotting, and softening variations in produce increases with storage duration. Mbuk *et al.* (2011) and Kereth *et al.* (2013) showed a positive though non-significant relationship for the number of days it takes to sell tomatoes, indicating that longer selling days result in greater spoilage and postharvest losses. Post-harvest losses of tomatoes and cabbage are mostly influenced by storage length; even a slight extension of storage time has a notable impact.

4.6.1.14 Access to the market information

Access to the market information to the sampled farmers had found negative though statistically insignificant relation among post-harvest losses of tomato and green pea crop. The result revealed that increase in access to the market information can lower the post-harvest losses in tomato and green pea crops. On the other hand, a positive and statistically insignificant relationship was observed between access to the market information and cabbage post-harvest losses. The study suggests that post-harvest losses of green peas could not be reduced by expanding access to market information.

4.7 Various field-to-market-level loss conditions which leads maximum damage to selected vegetable crops

The preceding tables shows that the overall post-harvest losses in study area for selected vegetable crops such as tomato, cabbage, and green pea crop towards the consumption end of the post-harvest distribution chain were approximately 5 to 10 per cent of harvest quantity. There are numerous post-harvest conditions that cause losses in selected vegetable crops. Farmers of three selected district i.e. Solan, Mandi and Shimla of Himachal Pradesh were asked to indicate the ranks to the conditions of post-harvest losses such as transportation, storage, handling damages, under/over maturity, marketing, environmental conditions, Storage pest and disease, rotting, cleaning and grading, packaging etc. which cause maximum losses in tomato, cabbage and green pea crop.

4.7.1 Various field-to-market-level loss conditions which lead maximum damage to Tomato crop produce

Table 4.39 Various field-to-market-level loss conditions which lead maximum damage to Tomato crop produce in the study area

Tomato Crop Produce								
PHL in diff Condition	**Solan**		**Mandi**		**Shimla**		**Overall**	
	Average Score	**Rank**	**Average Score**	**Rank**	**Average Score**	**Rank**	**Average Score**	**Rank**
Transportation	39.7	**VIII**	52.19	**VII**	50.05	**VII**	47.1	**VII**
Storage	34.38	**X**	45.64	**IX**	39.50	**X**	39.8	**X**
Handling Damages	42.25	**VI**	56.75	**V**	50.16	**VI**	49.7	**VI**
Under/Over maturity	46.25	**V**	58.00	**IV**	55.03	**V**	53.3	**V**
Inadequate market facility	51.12	**IV**	61.63	**III**	59.63	**III**	57.5	**III**
Environmental conditions	64.17	**II**	63.92	**II**	65.99	**II**	64.7	**II**
Pest and Disease	67.18	**I**	65.23	**I**	67.08	**I**	66.5	**I**
Rotting	56.98	**III**	53.42	**VI**	57.65	**IV**	56	**IV**
Cleaning and Grading	40.16	**VII**	48.03	**VIII**	44.48	**VIII**	44.2	**VIII**
Packaging	37.50	**IX**	43.16	**X**	41.12	**IX**	40.6	**IX**

Source: Field Survey, 2022-23

The facts reported in table 4.39 illustrate the key issues that farmers confront while marketing tomato crop. In the Himachal Pradesh district of Solan, the average percentage score of Garrett ranking was found to be highest (Rank I) 67.18 with losses due to pest and disease, followed by environmental conditions (Rank II) that was 64.17, rotting of tomato produce (Rank III) that was 56.98, losses during marketing of tomato produce (Rank IV) 51.12, under/over maturity, handling damages, cleaning and grading, transportation, packaging, and the lowest rate of loss occurred due to storage because the majority of respondents do not use storage facilities. Whereas, in Mandi and Shimla district also the average percentage score of Garrett ranking was found to be highest (Rank I) 65.23 and 67.08 with pest and disease in tomato produce, losses due to environmental conditions such as temperature, weather, rainfall etc. (Rank II) was 63.92 and 65.99 followed by marketing loss (Rank III) was 61.63 and 59.63. In Mandi district the cause of losses tomato crop due to the harvesting done at under/over maturity stage of tomato (Rank IV) followed by damages done due to the improper handling (Rank V), tomato lost due to the rotting (Rank VI), transportation lost (Rank VII) such as loading, unloading and overloading of tomato during transportation of tomato from filed to market, losses due to cleaning and grading of tomato produce (Rank VIII), Storage and Packaging were in last ranks because the sampled farmers were not used any warehouse facilities and for packaging the farmers used crates. Rotting (Rank IV) caused higher losses in the Shimla district than under/over matured tomato crop (Rank V) and damage due to improper handling (Rank VI), followed by transportation, cleaning & grading, packaging, and storage.

Overall, cause of maximum loss in tomato crop done due to pest and disease with average Garrett percentage score of 66.5 was the prominent condition and ranked first by the sampled farmers in the study area followed by environment condition due to which tomato produce lost (64.7) was ranked second, marketing loss due to receiving less price of tomato produce, distance of the market etc. was ranked in 3rd position with the mean score (57.5). Lenné and Ward, (2010) also reported that post-harvest losses have been recorded to 50% in Kenya and Tanzania, dependent upon the environmental conditions and distance from markets. Post-harvest losses due to rotting of tomato was in ranked IV because to improper handling techniques which also cause mechanical damage to the harvested produce in all the constraints faced by farmers in the marking of tomato produce. The study found that the major causes for losses in tomato produce were reported to be pest and disease, followed by environmental conditions, which have a direct impact on tomato marketing and result in farmers receiving lower prices for their produce.

4.7.2 Various field-to-market-level loss conditions which lead maximum damage to Cabbage crop produce

Table 4.40 revealed the conditions of post-harvest losses that cause maximum damage in cabbage crop. It is clear from the data above that in the Solan district of Himachal Pradesh, environmental conditions caused the most damage to the farmers' cabbage crop (Rank I), with an average percentage score of Garrett ranking of 70.45, followed by losses due to pest and disease was in rank with mean score 70.45 (Rank II). Lenné and Ward, (2010) also reported that post-harvest losses have been recorded to 50% in Kenya and Tanzania, dependent upon the environmental conditions and distance from markets. inadequate marketing facility loss which include low price for the produce, unsanitary in the market, distant market and lack of refrigeration in the market with rank III (64.67), cabbage harvest at under/over matured stage with 63.71 (Rank IV), improper handling or placing of produce (Rank V) with 62.07, losses occur due to transportation with 60.76 (Rank VI). Gariaki (2014) also reported that lack of chilling facilities and transportation systems contributes to post-harvest losses. Losses due to cleaning and grading of the crop (Rank VII) with 56.91 were the post-harvest conditions that cause maximum damage in the cabbage crop. The research findings indicate from the study area of Himachal Pradesh that post-harvest conditions like rotting, packaging, and storage were the least detrimental to the cabbage crop. The Mandi district sampled responder reported that the primary causes of post-harvest losses of cabbage were environmental condition (Rank I) with an average percentage score of 67.40, followed by losses due to pest and disease (Rank II) was 66.46, sometimes cabbage grower harvest the immature crops either to target the timely market of the produce to avoid the field losses due to the environmental conditions (Rank III) was 61.38, loss done in the process of cleaning and grading of produce (Rank IV), marketing losses because farmers weren't able to get a fair price for their produce in the market (Rank V), transportation loss due to the injury during loading, unloading of the produce (Rank VI), damages due to improper handling (Rank VII). In Shimla district also farmers revealed that cabbage crop losses maximized due to environmental conditions (Rank I) was 69.00, then losses due to pest and disease ranked second with 66.46, followed by marketing loss rank third with 62.08, produce loss due to under/over maturity rank fourth with 60.57, damage due to improper handling during marketing of cabbage crop rank fifth with 57.56, transportation etc.

Table 4.40 Various field-to-market-level loss conditions which lead maximum damage to Cabbage crop produce in the study area

Cabbage Crop Produce								
PHL in diff Condition	**Solan**		**Mandi**		**Shimla**		**Overall**	
	Average Score	**Rank**	**Average Score**	**Rank**	**Average Score**	**Rank**	**Average Score**	**Rank**
Inadequate market facility	64.67	**III**	64.01	**V**	62.08	**III**	61.9	**III**
Rotting	49.38	**VIII**	50.96	**VIII**	45.63	**VIII**	49.1	**VIII**
Cleaning and grading	56.91	**VII**	55.63	**IV**	54.43	**VII**	56.9	**VII**
Transportation	60.76	**VI**	60.97	**VI**	57.46	**VI**	58.7	**V**
Under/over maturity	63.71	**IV**	61.38	**III**	60.57	**IV**	61.6	**IV**
Pest and disease	70.45	**II**	66.46	**II**	66.46	**II**	66.6	**II**
Environmental condition	70.52	**I**	67.40	**I**	69.00	**I**	67.3	**I**
Handling damages	62.07	**V**	57.11	**VII**	57.96	**V**	57.7	**VI**
Packaging	44.37	**IX**	44.14	**IX**	41.98	**IX**	44.5	**IX**
Storage	41.36	**X**	41.44	**X**	40.77	**1X**	42.1	**X**

Source: Field Survey, 2022-23

Overall, the sampled farmers concluded that the most post-harvest losses occur in the cabbage crop due to environmental conditions (67.3) such as temperature, humidity, weather, rainfall etc. was ranked first, as well as losses caused by pest and disease (61.9) was ranked second, market losses (66.6) that result from farmers in the study area not being able to get a fair price for their produce and unsanitary in the market, crowded and lack of refrigeration in the market was ranked third, and some losses caused by early and late harvesting to target a timely market (61.6) was ranked fourth, losses occur due to transportation such as inadequacy of roads facility, careless handling during loading and unloading of cabbage produce (58.7) was ranked fifth. The study indicated that farmers in Himachal Pradesh require storage facilities to prevent such losses since, due to insufficient storage facilities; farmers were compelled to put their produce on the market in whatever condition.

4.7.3 Various field-to-market-level loss conditions which lead maximum damage to Green pea crop produce

The conditions that sampled farmers deal with that result in the maximum losses while marketing green pea crops was presented in Table 4.41. According to research, the average percentage score of Garrett ranking in the Solan district of Himachal Pradesh was determined to be highest (Rank I) due to pest and disease (71.58) followed by losses due to environmental conditions (Rank II) that was 70.58. Lenné and Ward, (2010) also reported that post-harvest losses have been recorded in Kenya and Tanzania, dependent upon the environmental conditions and distance from markets. Losses due to inadequate marketing facilities which include unsanitary in the market, distant market and lack of refrigeration in the market of green peas (Rank III) that was 66.47, losses during transportation of green pea from field level to marketing level (Rank IV) 63.73, Under/over maturity rank fifth (63.20) and it occurs when farmers harvest food before it reaches maturity or over matured to target higher markets, but obtain lower prices due to the small size of the green pea seed or over matured seed, losses due to improper handling damages of produce (Rank VI) was 59.99 , cleaning and grading (Rank VII) was 52.73, losses occur in green pea crop due packaging (Rank VIII) because majority of sampled farmers used proper packaging practice during marketing of produce, and the lowest rate of loss occurred due to storage because the majority of respondents do not use storage facilities. Whereas, in Mandi and Shimla district also the average percentage score of Garrett ranking was found to be highest (Rank I) 63.00 and 68.63 with losses occur in green pea crop due to different environment conditions such as temperature, weather, rainfall etc. Whereas, pest and disease losses (Rank II) was 61.71 and 66.08, followed by losses in the marketing due to lack of refrigeration facility, infrastructural facility (Rank III) was 60.28 and 65.29, the cause of green pea crop losses due to the harvesting done at under/over maturity stage (Rank IV) was 59.28 and 61.68, followed by transportation lost such as loading, unloading, overloading of produce during transportation , inadequate road facilities and transportation done during high temperature from filed to market (Rank V) was 58.63 and 60.57. In Mandi district losses occur due to the cleaning and grading of produce before marketing and during marketing (Rank VI) was 58.33, losses due to rotting (Rank VII), due to improper handling of green pea crop losses occur (Rank VIII) was 51.71. Whereas, due to improper handling (Rank VI) causes more losses in the Shimla district than losses done through cleaning & grading of green pea crop (Rank VII) and losses occur in green pea crop due to rotting of produce (Rank VIII) was 48.03. Storage and packaging were in last ranks in both the district i.e. Mandi and Shimla because the sampled farmers were not used any warehouse facilities and for packaging the farmers used proper packaging practices.

Table 4.41 Various field-to-market-level loss conditions which lead maximum damage to Green pea crop produce

PHL in diff Condition	Green Pea Crop Produce							
	Solan		Mandi		Shimla		Overall	
	Average Score	Rank	Average Score	Rank	Average Score	Rank	Average Score	Rank
Inadequate market facility	66.47	**III**	60.28	**III**	65.29	**III**	64.01	**III**
Rotting	50.93	**VIII**	53.93	**VII**	48.03	**VIII**	50.96	**VIII**
Cleaning and grading	52.73	**VII**	58.33	**VI**	55.82	**VII**	55.63	**VII**
Transportation	63.73	**IV**	58.63	**V**	60.57	**V**	60.97	**V**
Under/over maturity	63.20	**V**	59.28	**IV**	61.68	**IV**	61.38	**IV**
Pest and disease	71.58	**I**	61.71	**II**	66.08	**II**	66.46	**II**
Environmental condition	70.58	**II**	63.00	**I**	68.63	**I**	67.40	**I**
Handling damages	59.99	**VI**	51.71	**VIII**	59.63	**VI**	57.11	**VI**
Packaging	41.12	**IX**	48.48	**IX**	42.82	**IX**	44.14	**IX**
Storage	40.46	**X**	45.32	**X**	38.53	**X**	41.44	**X**

Source: Field Survey, 2022-23

Overall, the sampled farmers concluded that the most post-harvest losses occur in the green pea crop due to environmental conditions (67.40) such as temperature, humidity, weather, rainfall etc. was ranked first, as well as losses caused by pest and disease (66.46) ranked second, losses occur due to the inadequate market (64.01) was ranked third, and some losses caused by early and late harvesting mean losses due to harvesting of under/over matured produce to target a timely market (61.38) was ranked fourth, losses occur due to transportation such as inadequacy of roads facility , careless handling during loading and unloading of cabbage produce (60.97) was ranked fifth, losses due to improper handling of produce during filed to market level was rank sixth (57.11). According to the sampled farmers, packaging and storage procedures lost a minor quantity of crops since farmers in the research region utilized suitable packaging material during green pea harvest and because farmers in the study area have no storage facilities to preserve their produce, so they sell it straight in the market. The study indicated that farmers in Himachal Pradesh require storage facilities to prevent such losses since, due to insufficient storage facilities; farmers were compelled to put their produce on the market in whatever condition.

4.8 Management practices implemented by the farmers during marketing of vegetables to reduce Post-harvest Losses

The losses of vegetable crops are estimated to the around 20-50 per cent (Kader, 2005). However, it is important to implement the management practices for reducing post-harvest losses. Harvesting is an important procedure which affects the quality and shelf life of agricultural produce and helps to avoid wasting a large amount of vegetables. The goals are to maximize agricultural output, reduce losses and quality deterioration, and retain harvested products in great condition until sale or consumption. After harvesting, temperature control plays a critical role in minimizing postharvest losses and maximizing shelf life. Often, the most expensive component of the marketing route is transportation. Fresh fruit and vegetable transportation is based on the products worth, perishability, and distance from the point of origin (Harris, 1988). Fresh produce has a short shelf life at ambient temperature, which can range from a few hours to a few weeks. Using better packaging might significantly lower the prevailing postharvest loss of fruits and vegetables (Verma, 2000). The management strategies used by the sampled farmers to mitigate the losses of particular vegetables such as tomato, cabbage and green pea were also identified in this study.

4.8.1 Determine the components of management practices that farmers implement to mitigate post-harvest losses in Tomato crops: Factor Analysis

Management practices or strategies implemented by the sampled farmers in the study area of Himachal Pradesh were studied by constructing the different factors on reducing post-harvest losses. Principal component method has been used to reduce the number of factors and identify the most important factors which were adopted by the farmers to reduce the post-harvest losses of tomato crop in the research area.

Table 4.42 Descriptive statistics: Importance of variables in implementation of farm management practices to reduce Tomato post-harvest losses

Variables	Mean	Std. Deviation
Harvesting done at proper mature stage of tomato	4.21	0.942
Harvesting done by mechanical tools	2.04	0.842
Harvesting done by the trained or skill workers	3.69	1.043
Harvesting done in morning/evening hours	4.09	0.915
Remove vegetables which are damaged	4.27	0.682
Remove vegetables which are infected with disease	4.20	0.732
Remove vegetables which are over matured	4.17	0.750
Remove vegetables which are rotten	4.21	0.845
Washing treatment to the tomato	2.60	1.573
Waxing treatment to the tomato	1.94	1.064
Pre-cooling treatment to the tomato	1.87	1.175
Pest or fungus treatment to the tomato	2.70	1.458
Crates of tomato are not overfilled during packaging	4.47	0.663
Provide good aeration to the produce	4.33	0.683
Use good packaging material	4.57	0.634
Careful handling during loading and unloading	4.61	0.522
Use clean and ventilated vehicle	4.30	0.720
Transportation done during cool hours	4.01	1.063
Transportation done in refrigerated trucks	1.87	1.160

Source: Field Survey, 2022-23

The descriptive statistical analysis of significant farm management strategies used by tomato producers in the study region to reduce marketing losses is shown in Table 4.42. Table 4.42 analysis showed that, in order to minimize tomato crop losses in the study area, farmers prioritize careful handling while loading and unloading of the produce, which has the highest mean score (4.61). This is followed by using good packaging material (4.57), making sure tomato crates were not overfilled (4.47), providing good aeration to the produce (4.33), and using a clean, ventilated vehicle during cool hours (4.30). In contrast, the research area's examined farmers comprehended less about the pre-cooling process for tomatoes (1.87) and the transportation of tomatoes in refrigerated trucks, which had a mean score of 1.87. It was found that tomato producers have not embraced the management strategies, such as using refrigerated trucks for shipping and pre-cooling tomato treatments, as much. However, it was noted that farmers in the research region apply these farm management techniques in order to minimize losses, which highlights the need of treating objects carefully and using quality packaging materials.

Table 4.43 Kaiser-Meyer-Olkin and Bartlett's test of Sphericity for Tomato in the study area

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.702
Bartlett's test of sphericity	Approx. Chi-Square	25577.961
	Df	120
	Sig.	.000

Bartlett's test of sphericity showed a very significant value, indicating that factor analysis was adequate. Table 4.43 displayed the Kaiser-Meyer-Olkin values (KMO=0.702), which exceed the minimum required of 0.50. In a similar vein, the correlation matrix has significance data if the number of significant Bartlett's test results is equal to 0.00 and is lower than the significant threshold 0.05. Both criteria are considerably satisfied by the current investigation. The Kaiser rule is implemented to eliminate components that state that any values with Eigen values less than 1.0 should be eliminated. Five of the nineteen components in this data have Eigen values larger than one, and these principle components play the most important role in the study.

Communalities

Communalities measure the variance in a variable explained by all factors and are considered the reliability of indicators. They determine the correlation between an item and all others. In principal component analysis the initial value of communality is 1. Higher communalities indicate more variance, making higher extraction values suitable for factor analysis, while low extraction values are not. It has been determined that communalities for the chosen variables are trustworthy while performing factor analysis. The above table 4.44 was revealed that the variable such as harvesting of tomato crop done in morning/evening hours by the sampled farmers has the highest extraction value (0.82) and use clean and ventilated vehicle during transportation has lowest extraction value among all the variables i.e. (0.54).

Table 4.44 Communalities of the variables in implementation of farm management practices to reduce Tomato post-harvest losses in study area

Variables	Initial	Extraction
Harvesting done by the trained or skill workers	1.00	0.80
Harvesting done in morning/evening hours	1.00	0.82
Remove vegetables which are damaged	1.00	0.69
Remove vegetables which are infected with disease	1.00	0.80
Remove vegetables which are over matured	1.00	0.73
Remove vegetables which are rotten	1.00	0.61
Washing treatment to the tomato	1.00	0.67
Waxing treatment to the tomato	1.00	0.76
Pre-cooling treatment to the tomato	1.00	0.82
Pest or fungus treatment to the tomato	1.00	0.66
Crates of tomato are not overfilled during packaging	1.00	0.68
Provide good aeration to the produce	1.00	0.76
Use good packaging material	1.00	0.74
Careful handling during loading and unloading	1.00	0.54
Use clean and ventilated vehicle	1.00	0.72
Transportation done during cool hours	1.00	0.69

Extraction Method: Principal Component Analysis

The component factor loadings for different farm management practices for minimizing post-harvest losses are represented in Table 4.45. It was resulted from the research out of nineteen, five components have eigen values greater than one and these components play important role in the analysis. The total cumulative variability was 70.270 per cent explained by the included five principle components. It was revealed from the table that first eigen value (2.94) explained maximum variability (18.42%), the second eigen value (2.71) explain second highest variability (16.97%) followed by third eigen value (2.22) explain third highest variability. The first factor accounts for maximum variability in the adoption of farm management practices to reduce post-harvest losses in tomato crops. It mean that farmers adoption behavior related to reduce the post-harvest losses in tomato crop was associated with the removal of tomatoes which were infected with disease, over matured, damaged and rotten since their correlation with PC1 was higher than 0.5 followed by second factor (PC2) was highly correlated with pre-cooling, waxing, washing and pest-disease treatments to the crop. Likewise, the third component (PC3) mainly comprises the good aeration to the produce, use quality packaging material and crates of tomatoes were not overfilled. The eigen value of fourth component (PC4) was 1.97 which explain 12.33 per cent of total variance and showed that transportation done during cool hours, use clean and ventilated vehicle and careful handling during transportation play a significant role were the management practices adopt by the farmers for minimizing the post-harvest loss in tomato crop. The fifth component (PC5), eigen value was 1.70 and explain 18.65 total variance and comprise the harvesting done in cools hours and by skilled labor. However ignoring the significance correlation i.e. less than 0.50, the extracted factors are expressed in the form of following equations.

$$\mathbf{PC_1 = 0.882X_1 + 0.833X_2 + 0.820X_3 + 0.744X_4}$$

$$\mathbf{PC_2 = 0.897X_5 + 0.869X_6 + 0.777X_7 + 0.656X_8}$$

$$\mathbf{PC_3 = 0.854X_9 + 0.807X_{10} + 0.758X_{11}}$$

$$\mathbf{PC_4 = 0.820X_{12} + 0.803X_{13} + 0.649X_{14}}$$

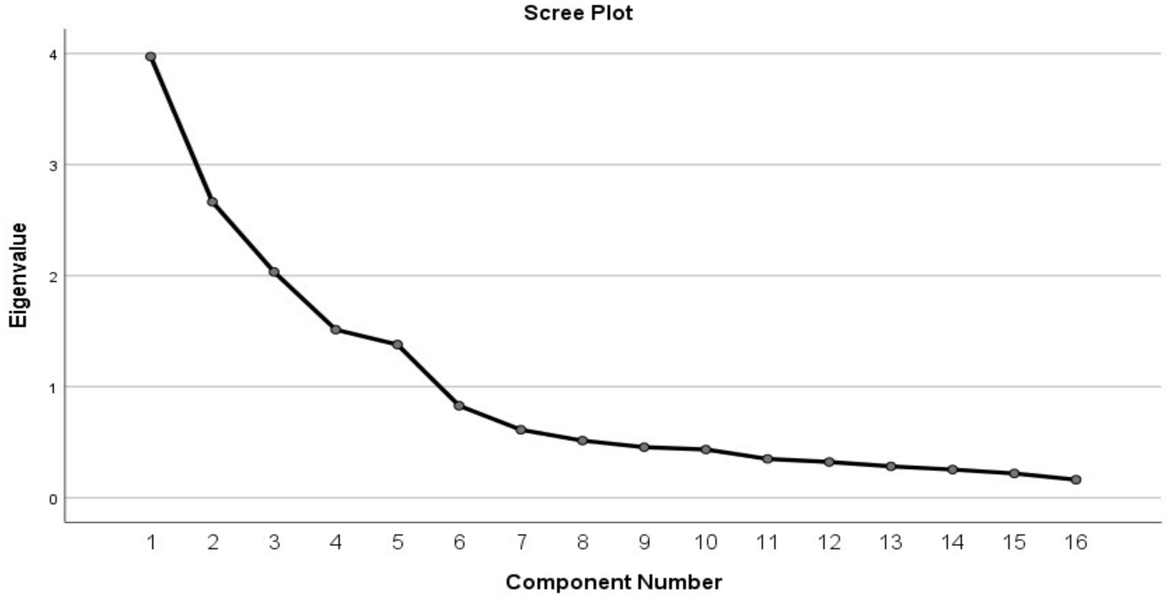
$$\mathbf{PC_5 = 0.895X_{15} + 0.867X_{16}}$$

Table 4.45 Eigen value, Variance (%) and cumulative variance (%) by the principal components (PCs) for Tomato crop

Variables	Components				
	PC1	PC2	PC3	PC4	PC5
Remove vegetables which are infected with disease	**0.882**	0.061	0.107	0.002	0.091
Remove vegetables which are over matured	**0.833**	0.039	0.189	0.032	0.086
Remove vegetables which are damaged	**0.820**	-0.045	0.111	0.069	-0.091
Remove vegetables which are rotten	**0.744**	0.154	0.139	0.035	0.138
Pre-cooling treatment to the tomato	0.091	**0.897**	0.050	-0.012	-0.083
Waxing treatment to the tomato	-0.088	**0.869**	-0.036	-0.012	-0.013
Pest or fungus treatment to the tomato	0.098	**0.777**	0.156	-0.141	0.083
Washing treatment to the tomato	0.159	**0.656**	-0.032	0.360	-0.291
Provide good aeration to the produce	0.060	0.041	**0.854**	0.147	-0.075
Use good packaging material	0.184	0.192	**0.807**	0.125	0.071
Crates of tomato are not overfilled during packaging	0.312	-0.089	**0.758**	0.058	0.007
Transportation done during cool hours	-0.050	-0.109	-0.101	**0.820**	0.007
Use clean and ventilated vehicle	-0.011	0.123	0.250	**0.803**	0.030
Careful handling during loading and unloading	0.209	-0.018	0.280	**0.649**	0.002
Harvesting done in morning/evening hours	0.083	-0.001	0.056	-0.116	**0.895**
Harvesting done by the trained or skill workers	0.100	-0.127	-0.070	0.159	**0.867**
Eigen Value	**2.947**	**2.715**	**2.221**	**1.974**	**1.705**
Variance (%)	**18.421**	**16.971**	**13.883**	**12.338**	**10.657**
Cumulative variance (%)	**18.421**	**35.392**	**49.275**	**61.613**	**70.270**

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization

Figure 4.20 Scree plot diagram of components in PCA for Tomato crop produce



Scree plot

The scree plot is simply a line segment plot that displayed (fig. 4.20) the eigenvalues for each individual principal component, with the number of variables on the x-axis and the eigenvalues on the y-axis. The eigenvalues were displayed in a downward curve, with the largest eigenvalue being the first, the next few explaining moderate amounts of variability, and the remaining factors explaining a small portion of the overall variability.

4.8.2 Determine the components of management practices that farmers implement to mitigate post-harvest losses in Cabbage crops: Factor Analysis

Table 4.46 presents a detailed analysis of farm management strategies used by cabbage producers in the study region to reduce marketing losses. Table 4.46 research revealed that farmers prioritize using superior packaging material for packing, with the highest mean score (4.59), in order to reduce losses from cabbage crops in the study region. This is followed by careful handling during loading and unloading of the commodity (4.54), providing good aeration to the produce (4.35), Gunny bags of cabbage were not overfilled during packing (4.34), and harvesting done at correct mature stage of cabbage (4.30). The research area's surveyed farmers, on the other hand, focused less about the pre-cooling treatment (1.79), the waxing treatment (1.71), and the transportation of cabbage in refrigerated trucks (1.87), respectively. The study reveals that cabbage producers in the research region were not as enthusiastic about using management strategies like refrigerated trucks for shipping and waxing and pre-cooling treatment of cabbage crop after harvest, despite their use to minimize losses, emphasizing the importance of careful produce treatment, proper harvesting, and quality packaging materials.

Table 4.46 Descriptive statistics: Importance of variables in implementation of farm management practices to reduce Cabbage post-harvest losses

Variables	Mean	Std. Deviation
Harvesting done at proper mature stage of cabbage	4.30	0.94
Harvesting done by mechanical tools	2.36	1.05
Harvesting done by the trained or skill workers	3.71	1.09
Harvesting done in morning/evening hours	4.08	0.95
Remove cabbage which are damaged	4.14	0.77
Remove cabbage which are infected with disease	4.11	0.78
Remove cabbage which are over matured	4.08	0.86
Remove cabbage which are rotten	4.11	1.02
Washing treatment to the cabbage	2.10	1.48
Waxing treatment to the cabbage	1.71	0.96
Pre-cooling treatment to the cabbage	1.79	1.06
Pest or fungus treatment to the cabbage	2.90	1.42
Gunny bags of cabbage are not overfilled during packaging	4.34	0.65
Provide good aeration to the produce	4.35	0.67
Use good packaging material	4.59	0.64
Careful handling during loading and unloading	4.54	0.60
Use clean and ventilated vehicle	4.24	0.81
Transportation done during cool hours	4.14	0.96
Transportation done in refrigerated trucks	1.87	1.27

Source: Field Survey, 2022-23

Table 4.47 Kaiser-Meyer-Olkin and Bartlett's test of Sphericity for Cabbage in the study area

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.582
Bartlett's test of sphericity	Approx. Chi-Square	1964.319
	Df	120
	Sig.	.000

The findings of the Kaiser-Meyer-Olkin test (KMO=0.582) in Table 4.47 are greater than the minimum of 0.50 that is advised, and the use of factor analysis is suitable as evidenced by the very significant value of Bartlett's test of sphericity. In a similar vein, the correlation matrix has significance data if the number of significant Bartlett's test results is equal to 0.00 and is lower than the significant threshold 0.05. The study in concern strongly passes both criteria. The Kaiser rule is applied to remove components which indicate that any values with Eigen values less than 1.0 have to be discarded. Five of the nineteen components in the results have Eigen values larger than one, and these are the primary components in the study.

Table 4.48 Communalities of the variables in implementation of farm management practices to reduce Cabbage post-harvest losses in study area

Variables	Initial	Extraction
Harvesting done by the trained or skill workers	1.00	0.72
Harvesting done in morning/evening hours	1.00	0.69
Remove vegetables which are damaged	1.00	0.66
Remove cabbage which are infected with disease	1.00	0.75
Remove cabbage which are over matured	1.00	0.64
Remove cabbage which are rotten	1.00	0.39
Washing treatment to the cabbage	1.00	0.68
Waxing treatment to the cabbage	1.00	0.80
Pre-cooling treatment to the cabbage	1.00	0.81
Pest or fungus treatment to the cabbage	1.00	0.61
Gunny bags of cabbage are not overfilled during packaging	1.00	0.52
Provide good aeration to the produce	1.00	0.71
Use good packaging material	1.00	0.68
Careful handling during loading and unloading	1.00	0.49
Use clean and ventilated vehicle	1.00	0.70
Transportation done during cool hours	1.00	0.55

Extraction Method: Principal Component Analysis

Communities

Communities are considered as reliable indicators since they estimate the variance in an indicator that can be explained by every factor. They identify the relationship between each item along with every other one. Greater variation is indicated by larger communalities, hence higher extraction values are appropriate for component analysis, while lower extraction values are not. The reliability of factor analysis has been confirmed by examining communalities for the selected variables. Table 4.48 shows that the variable such as pre-cooling treatment to the cabbage has the maximum extraction value (0.81), whereas careful handling during loading and unloading has the lowest extraction value (0.49).

Table 4.49 Eigen value, Variance (%) and cumulative variance (%) by the principal components (PCs) for Cabbage crop

Variables	Components				
	PC1	PC2	PC3	PC4	PC5
Pre-cooling treatment to the cabbage	**0.899**	0.000	0.008	-0.027	0.022
Waxing treatment to the cabbage	**0.880**	0.001	-0.134	0.091	-0.074
Washing treatment to the cabbage	**0.622**	0.184	-0.104	0.139	-0.485
Pest or fungus treatment to the cabbage	**0.617**	-0.107	0.276	-0.308	0.218
Remove cabbage which are infected with disease	-0.032	**0.844**	0.084	-0.183	-0.022
Remove cabbage which are damaged	-0.154	**0.762**	0.147	-0.188	-0.092
Remove cabbage which are over matured	0.127	**0.726**	0.125	0.203	0.218
Remove cabbage which are rotten	0.091	**0.555**	0.002	0.273	0.033
Use good packaging material	-0.014	0.039	**0.826**	-0.028	0.003
Provide good aeration to the produce	0.047	0.075	**0.797**	0.263	-0.044
Gunny bags of cabbage are not overfilled during packaging	-0.086	0.313	**0.608**	0.209	0.067
Transportation done during cool hours	-0.040	-0.019	-0.043	**0.740**	0.066
Use clean and ventilated vehicle	0.096	-0.002	0.365	**0.738**	0.123
Careful handling during loading and unloading	-0.064	0.071	0.356	**0.585**	-0.134
Harvesting done by the trained or skill workers	-0.003	0.066	-0.051	0.136	**0.839**
Harvesting done in morning/evening hours	-0.016	0.059	0.026	-0.035	**0.829**
Eigen Value	**2.426**	**2.290**	**2.100**	**1.874**	**1.781**
Variance (%)	**15.161**	**14.314**	**13.124**	**11.714**	**11.130**
Cumulative variance (%)	**15.161**	**29.475**	**42.599**	**54.313**	**65.443**

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization

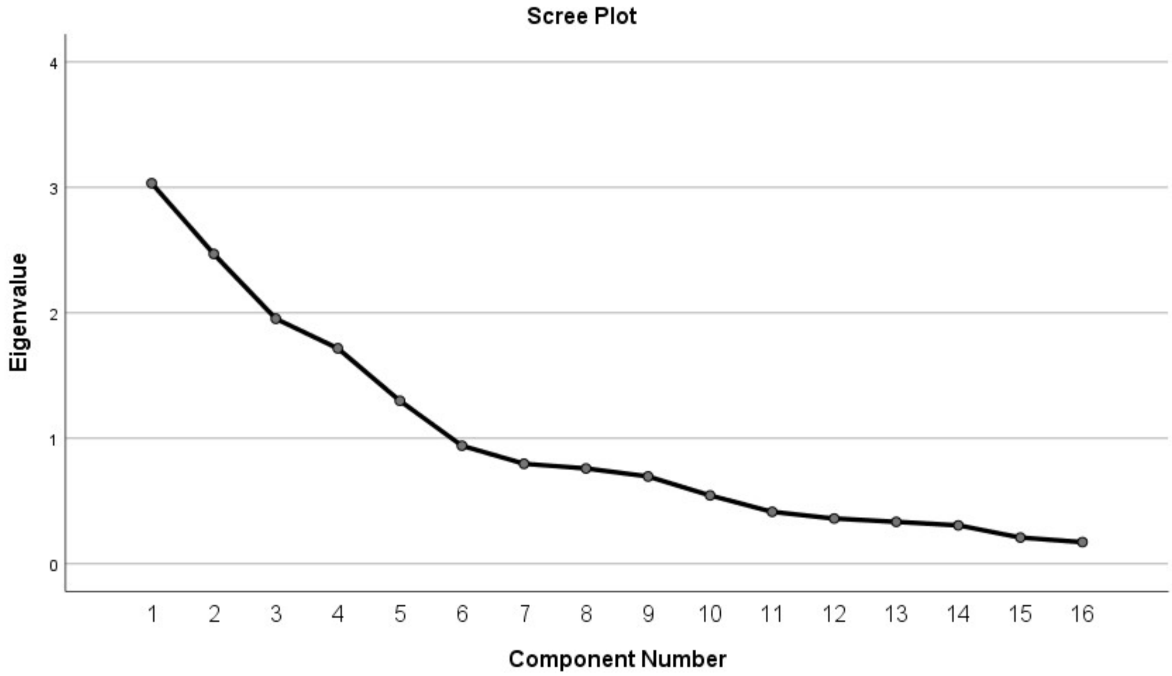
The component factor loadings for farm management strategies to reduce post-harvest losses are shown in Table 4.49. Five of the 19 components have eigenvalues larger than one, which is necessary for analysis. The five considered principal components explained 65.44 percent of the overall cumulative variability. According to the table, the first eigenvalue (2.42) described the largest amount of variability (15.16%), the second eigenvalue (2.29) explained the next-highest variability (14.31%), and the third eigenvalue (2.10) explained the third most variability (13.12). The first component accounts for the most variation in farm management strategies used to prevent post-harvest losses in cabbage crops. It means that farmers' adoption behavior related to reducing post-harvest losses in cabbage crop was associated with pre-cooling, waxing, washing, and pest-disease treatments to the crop because their correlation with PC1 was greater than 0.5, followed by second factor (PC2) which was strongly associated with removal of diseased, over matured, damaged, and rotten produce. The use of high-quality packing materials, enough aeration of the product, and well stocked cabbage crates make up the third component (PC3). In order to minimize post-harvest loss in the cabbage crop, farmers adopt management practices such as using clean, ventilated vehicles, handling carefully during transportation, and scheduling transportation during cool hours. The eigen value of the fourth component (PC4), which was 1.87, explained 11.71 percent of the total variance. The fifth component (PC5), which includes skilled labor and harvesting done during cool hours, has an eigen value of 1.78 and accounts for 11.13 of the total variation. These equations represent the extracted components, but they ignore the significant correlation, which is less than 0.50.

$$\mathbf{PC_1 = 0.899X_1 + 0.880X_2 + 0.622X_3 + 0.617X_4}$$
$$\mathbf{PC_2 = 0.844X_5 + 0.762X_6 + 0.726X_7 + 0.555X_8}$$
$$\mathbf{PC_3 = 0.826X_9 + 0.797X_{10} + 0.608X_{11}}$$
$$\mathbf{PC_4 = 0.740X_{12} + 0.738X_{13} + 0.585X_{14}}$$
$$\mathbf{PC_5 = 0.839X_{15} + 0.829X_{16}}$$

Scree Plot

With the number of variables on the x-axis and the eigenvalues on the y-axis, the scree plot is essentially a line segment plot that shows the eigenvalues for each unique primary component. The first eigenvalue had the biggest value; the following several explained modest amounts of variability; the other remaining variables explained a little part of the overall variability; the eigenvalues were presented in a descending curve.

Figure 4.21 Scree plot diagram of components in PCA for Cabbage crop produce



4.8.3 Determine the components of management practices that farmers implement to mitigate post-harvest losses in Green pea crops: Factor Analysis

To reduce post-harvest losses during marketing in the research region, the green pea growers implemented several farm management strategies, which are analyzed using descriptive statistics and presented in Table 4.50. With a mean score of 4.64, the study discovered that farmers in the study region set a high priority on utilizing better packing material to reduce losses in green pea crop. The study emphasizes the importance of careful handling during loading and unloading, ensuring crates and bags are not overfilled during packaging, providing good aeration, and removing rotten green peas. Farmers in the research area surveyed focused less on green pea waxing treatment (1.68) and pre-cooling treatment (1.71) and green pea transportation in refrigerated trucks (1.84). Based to the results, green pea growers in the study were less enthused about utilizing management techniques such as refrigerated vehicles for shipment as well as waxing and pre-cooling treatment, despite their usage to reduce losses and underline the necessity of meticulous product handling.

Table 4.50 Descriptive statistics: Importance of variables in implementation of farm management practices to reduce Green Pea post-harvest losses

Variables	Mean	Std. Deviation
Harvesting done at proper mature stage of green pea	4.19	0.983
Harvesting done by mechanical tools	2.25	1.042
Harvesting done by the trained or skill workers	3.69	1.126
Harvesting done in morning/evening hours	4.12	1.020
Remove green pea which are damaged	4.18	0.736
Remove green pea which are infected with disease	4.13	0.732
Remove green pea which are over matured	4.16	0.816
Remove green pea which are rotten	4.24	0.925
Washing treatment to the green pea	2.01	1.346
Waxing treatment to the green pea	1.68	0.912
Pre-cooling treatment to the green pea	1.71	1.037
Pest or fungus treatment to the green pea	2.85	1.425
Crates & gunny bags of green pea are not overfilled during packaging	4.44	0.721
Provide good aeration to the produce	4.38	0.674
Use good packaging material	4.64	0.607
Careful handling during loading and unloading	4.52	0.667
Use clean and ventilated vehicle	4.17	0.909
Transportation done during cool hours	4.06	1.060
Transportation done in refrigerated trucks	1.84	1.236

Source: Field Survey, 2022-23

Table 4.51 Kaiser-Meyer-Olkin and Bartlett's test of Sphericity for Green Pea in the study area

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.627
Bartlett's test of sphericity	Approx. Chi-Square	2030.853
	Df	120
	Sig.	.000

Table 4.51 presents the Kaiser-Meyer-Olkin results (KMO=0.627), above the acceptable minimum of 0.50. Additionally, the very significant value obtained from Bartlett's test of sphericity demonstrates that factor analysis is a suitable approach. In a similar vein, the correlation matrix has significance data if the number of significant Bartlett's test results is equal to 0.00 and is lower than the significant threshold 0.05. Both tests are considerably fulfilled by the present study. The Kaiser rule applies to eliminate components which mandate that any values with Eigen values less than 1.0 be dropped. For this data, five of the nineteen components have Eigen values larger than one, and these primary components play the most important role in the study.

Table 4.52 Communalities of the variables in adoption of farm management practices to reduce Green Pea post-harvest losses in study area

Variables	Initial	Extraction
Harvesting done by the trained or skill workers	1.00	0.65
Harvesting done in morning/evening hours	1.00	0.67
Remove green pea which are damaged	1.00	0.65
Remove green pea which are infected with disease	1.00	0.72
Remove green pea which are over matured	1.00	0.69
Remove green pea which are rotten	1.00	0.52
Washing treatment to the green pea	1.00	0.72
Waxing treatment to the green pea	1.00	0.80
Pre-cooling treatment to the green pea	1.00	0.81
Pest or fungus treatment to the green pea	1.00	0.55
Crates & gunny bags of green pea are not overfilled during packaging	1.00	0.59
Provide good aeration to the produce	1.00	0.76
Use good packaging material	1.00	0.69
Careful handling during loading and unloading	1.00	0.56
Use clean and ventilated vehicle	1.00	0.68
Transportation done during cool hours	1.00	0.63

Extraction Method: Principal Component Analysis

Communities

Communalities assess the reliability of indicators by measuring the variance in an attribute determined by all components. They establish the relationship between one item and all others. Larger communalities suggest more variation, hence larger extraction values are appropriate for component analysis, but low extraction values are unsuitable. And, measuring communalities for the selected variables validated the reliability of factor analysis. The variable such as pre-cooling treatment to the cabbage by the participant farmers has the greatest extraction value (0.81) and remove green peas that are deteriorating has the lowest extraction value (0.52) among all variables shows in Table 4.52.

Table 4.53 Eigen value, Variance (%) and cumulative variance (%) by the principal components (PCs) for Green Pea

Variables	Components				
	PC1	PC2	PC3	PC4	PC5
Pre-cooling treatment to the green pea	**0.892**	0.051	0.047	-0.124	-0.006
Waxing treatment to the green pea	**0.883**	-0.063	-0.139	0.005	-0.027
Washing treatment to the green pea	**0.747**	0.123	-0.103	0.093	-0.362
Pest or fungus treatment to the green pea	**0.556**	-0.062	0.230	-0.411	0.153
Remove green pea which are infected with disease	0.004	**0.820**	0.170	-0.109	-0.105
Remove green pea which are over matured	0.016	**0.784**	0.039	0.215	0.174
Remove green pea which are damaged	-0.065	**0.723**	0.195	-0.162	-0.252
Remove green pea which are rotten	0.149	**0.573**	0.010	0.226	0.352
Provide good aeration to the produce	0.005	0.037	**0.837**	0.257	-0.041
Use good packaging material	0.063	0.078	**0.816**	0.003	0.125
Crates & gunny bags of green pea are not overfilled during packaging	-0.155	0.303	**0.694**	0.016	-0.021
Use clean and ventilated vehicle	-0.007	-0.022	0.209	**0.801**	0.039
Transportation done during cool hours	-0.058	0.004	-0.060	**0.766**	0.211
Careful handling during loading and unloading	-0.116	0.121	0.230	**0.606**	-0.336
Harvesting done in morning/evening hours	-0.152	0.019	0.114	-0.140	**0.789**
Harvesting done by the trained or skill workers	-0.037	0.008	-0.026	0.173	0.**789**
Eigen Value	**2.540**	**2.276**	**2.116**	**2.040**	**1.805**
Variance (%)	**15.874**	**14.228**	**13.223**	**12.751**	**11.283**
Cumulative variance (%)	**15.874**	**30.102**	**43.325**	**56.076**	**67.359**

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization

Table 4.53 shows the component factor loadings for farm management strategies to reduce post-harvest losses. Five of the 19 components have eigenvalues larger than one, which is important for analysis. The five principal components that were considered accounted for 67.35% of the overall cumulative variability. The table showed that the first eigen value (2.54) described the greatest extent of variability (15.87%), the second eigen value, 2.27, explained the second highest variability (14.22%), and the third eigen value, 2.11, explained the third highest variability (13.22%). When it comes to adopting farm management techniques that minimize post-harvest losses in green pea crops, the first component explains the most variation. Since their correlation with PC1 was higher than 0.5, it follows that farmers' adoption behavior related to reducing post-harvest losses in green pea crops was associated with pre-cooling, waxing, washing, and pest-disease treatments to the crop. The second factor (PC2) was highly correlated with the removal of green pea that was disease-infected, over matured, damaged, and rotten. Similar to the previous instance, the third component (PC3) essentially consists of properly ventilating the green pea crates, using high-quality packing materials, and avoiding overfilling of green pea crates and gunny bags. In order to minimize post-harvest loss in green pea crops, farmers adopt management practices such as using clean, ventilated vehicles, handling produce carefully during transportation, and scheduling transportation during cool hours. The eigen value of the fourth component (PC4), which was 2.04, explained 12.75 percent of the variance overall. The fifth component (PC5), with an eigen value of 1.80, accounts for 11.28 total variance and includes harvesting done in cools hours and by skilled labor. The retrieved components were stated in the following equations; however the significant correlation—less than 0.50—is ignored.

$$\mathbf{PC_1 = 0.892X_1 + 0.883X_2 + 0.747X_3 + 0.556X_4}$$

$$\mathbf{PC_2 = 0.820X_5 + 0.784X_6 + 0.723X_7 + 0.573X_8}$$

$$\mathbf{PC_3 = 0.837X_9 + 0.816X_{10} + 0.694X_{11}}$$

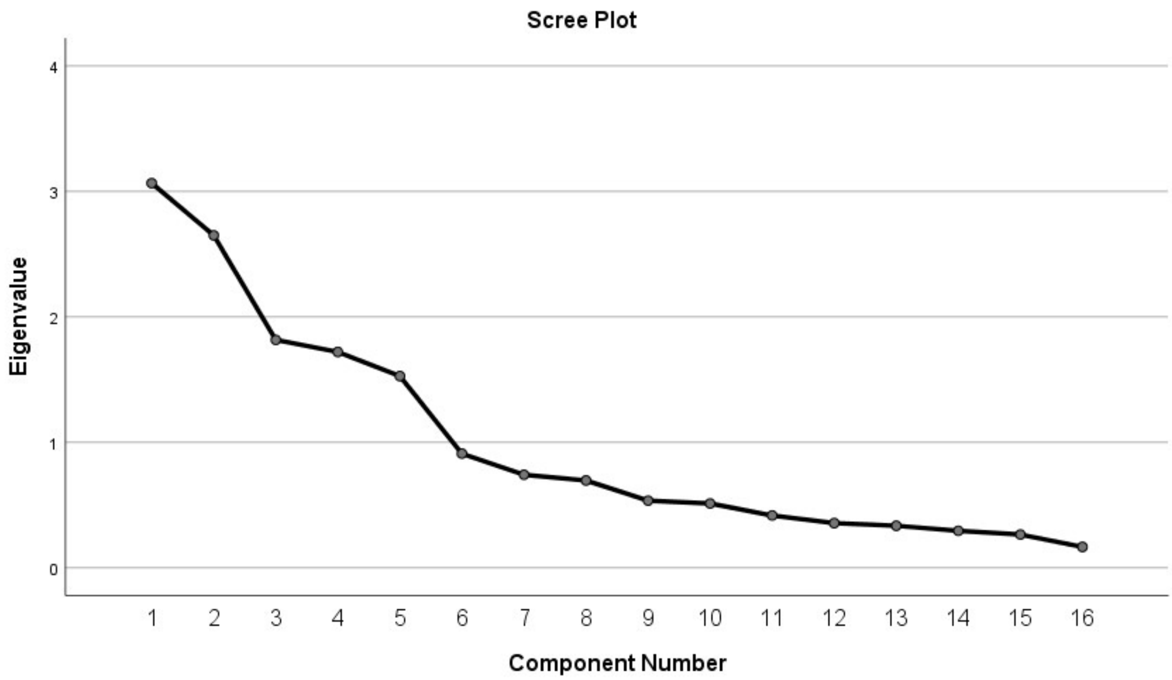
$$\mathbf{PC_4 = 0.801X_{12} + 0.766X_{13} + 0.606X_{14}}$$

$$\mathbf{PC_5 = 0.789X_{15} + 0.789X_{16}}$$

Scree Plot

The scree plot is essentially a line segment plot where the eigenvalues of each individual main component were shown on the y-axis and the number of variables on the x-axis. The eigenvalues were plotted in a decreasing order, with the first eigenvalue having the biggest value, the next components accounting for considerable levels of variability, and the remaining factors accounting for only a small portion of the total variability.

Figure 4.22 Scree plot diagram of components in PCA for Green Pea crop produce



4.9 Information source used by farmers to adopt farm management practices to reduce PHL

Information has a crucial role in rural and agricultural growth (Garforth *et al*., 2003). Information sources play a crucial role in explaining novel technology to users, fostering interest, comprehension, and motivation for adoption (Gupta and De, 2011). Information is critical in decision making, and its value is determined by its substance, relevance, and timely delivery. To get the correct information at an appropriate time, users must be aware of the many sources of information, services available, and current information systems (Jain, 2007). External knowledge, whether derived from formal study or created in other locations, can promote new thinking and behaviors, providing new ideas and raising awareness of new opportunities (Figueroa *et al*., 2002). An information seeker or an information expert who acts on their behalf can identify the information needs (Kaniki, 2001). To keep farmers' information demands updated and adapt to changes in their environment, it is crucial to conduct regular research (Kalusopa, 2005).

Table 4.54 Source of information used by farmers to reduce post-harvest losses of vegetable crops

Multiple Response Analysis			
Sources of Information	**Responses**		**Per cent of cases**
	N	**Per cent**	
Informal Sources			
Information by family members	134	6.9	37.2
Fellow/ Progressive farmers	223	11.4	61.9
Information by neighbors	229	11.7	63.6
Friends/relative	201	10.3	55.8
Formal Sources			
Extension functionaries of state government	79	4.0	21.9
Krishi Vigyan Kendra (KVK)	100	5.1	27.8
Scientists interaction	116	5.9	32.2
Agricultural / Horticultural Universities	162	8.3	45.0
Training/Seminar provided by government institutions	236	12.1	65.6
Mass Media Sources			
Newspaper and print media	109	5.6	30.3
Radio and TV	63	3.2	17.5
Mobile/Social media	299	15.3	83.1
Total	1951	100.0	541.9

Source: Field Survey, 2022-23

To lower post-harvest losses in particular vegetable crops, sampled farmers employed a variety of information sources, as Table 4.54 demonstrates. The study categorized the various information sources accessed into formal, mass media, and informal categories. The first group, informal sources of knowledge, comprised information from family members, fellow workers or progressive farmers, neighbors, friends, and relatives. The majority of farmers in the research region relied on information provided by their neighbors (63.6%) to use new management strategies to decrease post-harvest losses in the selected vegetable crops. Rahman *et al.*, 2016 also found the similar results. The second group is formal sources of knowledge, which include state government extension specialists, KVK, scientific interactions, agricultural or horticultural universities, and government-provided training or seminars. Farmers in the research region rely on information supplied by the government through training or seminars (65.6%) to decrease post-harvest losses in selected vegetable crops. The third category involves information obtained from mass media, which includes newspapers and print media, radio and television, mobile and social media. The majority of farmers relied on mobile and social media information to implement management strategies that reduced post-harvest losses in selected vegetable crops.

Overall, the preceding table makes it evident that the farmers' primary information source of choice was social media or mobile devices (83.1%). Farmers also relied on government-sponsored seminars and training (65.6%), neighbor recommendations (63.6%), and information from other progressive farmers (61.9%), information from friends and relatives (55.8%), relied on agricultural and horticultural universities for (45.0%) information about adopting management practices to reduce post-harvest losses. Only 17.5% of the farmers in the sample utilized radio or television to obtain information about the research region. The study concluded that majority farmers of study area were relied on the mass media. Farmers often rely on local resources during emergencies. Local sources may provide more effective solutions than foreign sources. Additionally, farmers examine the quality of information provided by a source. Farmers choose mobile or social media for information, training, and government-sponsored seminars with expert perspectives.

Section- D: Major constraints and suggestion for marketing and reducing post-harvest losses of selected vegetable crop

In the current environment of diversification, commercialization, and globalization, the value of vegetables has been increased many times over. However, because of ongoing deficiencies in the marketing system, post-harvest losses in vegetables are extremely high, and producers are unable to realize expected benefits. While losses cannot be completely avoided, they may be minimized by using suitable market techniques and gaining more knowledge of the nature of the produce. This section of the questionnaires covered the key constraints that faced by the farmers for managing the post-harvest losses and farmers suggestion for reducing post-harvest losses of selected vegetable crops in study area.

This objective focuses on identifying the difficulties or problems that farmers experience while seeking ways to mitigate or prevent post-harvest losses during the marketing of vegetables. The focus is on the constraints that prevent effective post-harvest loss management measures. The aim expands to investigate the financial, technical, infrastructural, and informational restrictions that farmers face while managing with post-harvest losses during marketing.

4.10 Constraints faced by the farmers for marketing of selected vegetable crops in the study area

In agriculture marketing constraints/challenges are never ended and post-harvest losses are one of the constraint/challenge that never ends. However, farmers can only minimize the losses by proper handling of agriculture produce. 28 constraints were identified and the sampled farmers of the selected districts of Himachal Pradesh were asked to indicate the rank to the constraints on five-point scale- extremely high (V), high (IV), moderate (III), low (II) and extremely low (I) faced by the farmers for managing the post-harvest losses during the marketing of selected vegetable crops and score them accordingly. The pre-harvest production practices also have a tremendous effect of post-harvest shelf life. The detailed crop-wise constraints related to production, marketing, education, financial, technical and infrastructure faced by the farmers of study area in marketing of selected vegetable crops were analyzed and results are presented below:

4.10.1 Constraints faced by the farmers for marketing of Tomato crops in the study area

Marketing of vegetable crops such as tomato crop is quite difficult and risky due to their perishable nature. Most of the tomato grower in study area is small scale farmers and they mainly depend on output of the production. It is however important to investigate the major constraints involved in marketing of tomato crop.

The constraints related to production, marketing, economic, education, financial, technical and infrastructure faced by the farmers of study area in marketing of tomato crops were presented in table 4.55. The Kendall's W was found 0.29, 0.46 and 0.56 for Solan, Mandi, Shimla district respectively, and Asymptotic significance was 0.000 which is significant ($p<0.01$). The null hypothesis was rejected in favour of the alternate hypothesis, which stated that the constraints faced by farmers in marketing of tomato crops were in agreement. Overall, Kendall's W value of 0.39 indicates that there was 39 per cent agreement between the farmers in ranking the constraints.

An analysis was made to identify the production related constraints faced by the tomato growers in study area. In Solan district and Shimla, non-availability of high yielding variety seed were the major constraint with a mean score of 15.60 and 11.46 (rank I).

Table 4.55 Problem faced by the farmers in marketing of Tomato crop in study area

Constraints	Tomato							
	Solan		Mandi		Shimla		Overall	
	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank
Production constraints								
Non availability of planting material on time	10.93	**IV**	5.69	**V**	6.91	**V**	7.84	**V**
Non availability of high yielding variety seed	15.60	**I**	10.53	**II**	11.46	**I**	12.53	**I**
Non availability of market information	13.14	**III**	9.77	**III**	9.74	**II**	10.88	**II**
Lack of irrigation facilities	9.82	**V**	12.45	**I**	7.90	**III**	10.06	**IV**
Non availability of labor on time	14.51	**II**	9.52	**IV**	7.39	**IV**	10.47	**III**
Marketing Constraints								
Lack of transportation	17.84	**III**	19.10	**V**	18.81	**IV**	18.58	**IV**
Fluctuation in marketing prices	20.38	**II**	21.45	**II**	23.00	**III**	21.61	**II**
Absence of regulated market	10.71	**VI**	20.12	**IV**	16.49	**V**	15.77	**V**
Distant market	12.82	**V**	18.33	**VI**	16.17	**VI**	15.77	**VI**
Lacking in grading and packaging	19.00	**IV**	21.39	**III**	23.26	**II**	21.22	**III**
Long chain of intermediaries	22.43	**I**	24.35	**I**	25.78	**I**	24.18	**I**
Financial Constraints								
High cost of planting material	16.20	**III**	15.46	**II**	16.24	**III**	15.97	**II**
High cost of pesticides and fertilizers	19.32	**I**	16.34	**I**	19.66	**I**	18.44	**I**
High cost of labor	15.06	**IV**	14.57	**IV**	17.16	**II**	15.59	**III**
Non-availability of credit in time	8.43	**VIII**	9.75	**VIII**	7.81	**VIII**	8.67	**VIII**
Low prices of the produce	17.71	**II**	14.57	**III**	13.50	**IV**	15.26	**IV**
High initial investment on infrastructure	11.03	**VI**	12.67	**V**	12.80	**V**	12.17	**V**
High payback period in investment	9.60	**VII**	10.78	**VII**	11.07	**VII**	10.48	**VII**
Unawareness of insurance facilities in case of risk	11.45	**V**	12.00	**VI**	11.73	**VI**	11.73	**VI**
Technical and Infrastructural								
Lack of proper infrastructural facilities	16.53	**IV**	14.90	**IV**	13.90	**IV**	15.11	**IV**
Non availability of vegetable growing and marketing related information through SMS/Internet	19.45	**III**	17.60	**III**	18.08	**III**	18.38	**III**
Lack of training on postharvest handling practices and technologies	19.59	**II**	22.79	**I**	22.40	**II**	21.59	**II**
Lack of storage and processing facility	21.54	**I**	22.43	**II**	25.70	**I**	23.22	**I**
Education Constraint								

Lack of basic knowledge about PHM practices	11.63	**I**	15.94	**I**	14.10	**I**	13.89	**I**
Lack of mass media exposure on this topic	10.18	**IV**	10.92	**II**	10.65	**II**	10.58	**II**
Lack of prior experience	8.89	**V**	8.57	**III**	8.78	**III**	8.74	**IV**
Lack of willingness to take initiative	10.61	**III**	7.58	**IV**	8.78	**IV**	8.99	**III**
Lack of motivation and skill about proper production	11.58	**II**	6.44	**V**	6.74	**V**	8.25	**V**
Number of observation	**120**	**120**	**120**	**360**				
Kendall's W	**0.29**	**0.46**	**0.56**	**0.39**				
Chi-square	**947.7**	**1519.9**	**1813**	**3821.7**				
df.	**27**	**27**	**27**	**27**				

Source: Field Survey, 2022-23

In Solan district and Shimla, non-availability of high yielding variety seed were the major constraint with a mean score of 15.60 and 11.46 (rank I), followed by non- availability of labor on time and non-availability of market information with a mean score of 14.51 and 9.74 (rank II). Similarly in Mandi district, lack of irrigation facilities was major constraint (rank I) with mean score of 12.45. At an overall level, it was resulted that non-availability of high yielding variety seed (12.53) and non-availability of market information (10.88) were two major production constraints experienced by the tomato growers in the study area.

Marketing of perishable produce is major challenge faced by the farmers. The above table also revealed that marketing constraints in the Solan, Mandi and Shimla district, long chain of intermediaries (rank I) was the major problem faced by the sampled farmers in the marketing of tomato crops. In the study area, most tomato crops are marketed through regional traders and intermediaries, who receive a fee, resulting in lower prices for farmers. Further, at overall level, it was revealed that long chain of intermediaries and fluctuation in marketing prices ranked I with mean score of 24.18 and 21.61 were the major marketing challenges faced by the farmers. Shah and Ansari (2020) also found that market intermediaries were the major marketing constraints for tomato crop experienced by farmers.

Financial constraints were affecting the livelihood of the individuals. Above table revealed that among the financial constraints faced by the sampled farmers high cost of pesticides and fertilizers were the most severe challenged experienced by the farmers of study area with mean score 19.32 in Solan, 16.32 in Mandi and 19.66 in Shimla respectively. Whereas, non-availability of credit in time (rank VIII) and high payback period in investment (rank VII) were the minor financial constraints faced by the farmers of study area with the mean score of 10.48 and 8.67. Rohit *et al.* (2017) and Jat *et al.* (2012) also found that high cost of fertilizers and manure was major financial constraint faced by the farmers.

The above table depicted that lack of storage and processing facilities was the major technical and infrastructural constraint (ranked I) faced by the respondent of Solan and Shimla districts with mean score of 21.54 and 25.77. Similarly, in Mandi district lack of training on postharvest handling practices and technologies (rank I) was the major problem perceived by the farmers with mean score 22.79. Overall, these two constraints were the important technical constraints faced by the farmers of study area followed by non-availability of vegetable growing and marketing related information through SMS/Internet (rank III) and lack of proper infrastructural facilities (rank IV) because the farmers in the study area felt that tomato crops are extremely perishable and they could not preserve the produce for a longer period of time, even in the storage houses.

Lack of basic knowledge about post-harvest management practices ranked in first position with the mean score 11.63 in Solan, 15.94 in Mandi and 14.10 in Shimla were the major education constraints experienced by the farmers of study area followed by lack of mass media exposure on this topic. Whereas, the minor education constraint faced by the sampled farmers was lack of motivation and skills about proper tomato production which ranked in fifth position with mean score of 8.25 in the study area. The significant limits mentioned by the majority of tomato producers could have been caused by the fact that education plays a vital role in eliminating societal biases and attitudes that restrict the acceptability of technology. Tomato producers were not in contact with accurate scientific information, and the official did not always work with the tomato growers due to a lack of technical knowledge.

4.10.2 Constraints faced by the farmers for marketing of Cabbage in the study area

Various challenges experienced by the cabbage grower of study area are studied and the results are presented in descending order by using Kendall W technique. The constraints which have highest mean value is considered to be the most significant constraint that causes high range of loss in the marketing of cabbage crop.

Table 4.56 Problem faced by the farmers in marketing of Cabbage crop in study area

Constraints	Cabbage							
	Solan		Mandi		Shimla		Overall	
	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank
Production constraints								
Non availability of planting material on time	10.89	**IV**	6.06	**V**	6.94	**V**	7.97	**V**
Non availability of high yielding variety seed	14.51	**II**	10.72	**II**	11.34	**I**	12.19	**I**
Non availability of market information	12.17	**III**	9.95	**IV**	9.79	**II**	10.64	**III**
Lack of irrigation facilities	10.78	**V**	12.45	**I**	8.03	**III**	10.42	**IV**
Non availability of labor on time	14.93	**I**	10.07	**III**	7.55	**IV**	10.85	**II**
Marketing Constraints								
Lack of transportation	13.38	**V**	18.54	**VI**	16.35	**VI**	16.09	**V**
Fluctuation in marketing prices of cabbage	22.10	**I**	24.25	**I**	25.60	**I**	23.98	**I**
Absence of regulated market	10.58	**VI**	19.92	**IV**	16.46	**V**	15.65	**VI**
Distant market	19.81	**III**	21.30	**III**	22.89	**III**	21.33	**II**
Lacking in grading and packaging	19.12	**II**	19.10	**V**	18.64	**IV**	18.95	**IV**
Long chain of intermediaries	18.24	**IV**	21.33	**II**	23.14	**II**	20.90	**III**
Financial Constraints								
High cost of planting material	17.12	**III**	15.81	**II**	16.35	**III**	16.43	**II**
High cost of pesticides and fertilizers	18.89	**I**	16.13	**I**	19.52	**I**	18.18	**I**

High cost of labor	15.70	**IV**	14.72	**III**	17.20	**II**	15.87	**III**
Non-availability of credit in time	8.54	**VIII**	10.07	**VIII**	7.82	**VIII**	8.81	**VIII**
Low prices of the produce	18.10	**II**	14.28	**IV**	13.60	**IV**	15.33	**IV**
High initial investment on infrastructure	12.05	**VI**	12.98	**V**	12.91	**V**	12.65	**V**
High payback period in investment	10.12	**VII**	11.05	**VII**	11.13	**VII**	10.77	**VII**
Unawareness of insurance facilities in case of risk	12.11	**V**	11.88	**VI**	11.83	**VI**	11.94	**VI**
Technical and Infrastructural								
Non availability of vegetable growing and marketing related information through Internet/SMS	21.49	**I**	22.04	**II**	25.65	**I**	23.06	**1**
Lack of training on PHH practices and technologies	19.07	**II**	17.73	**III**	18.13	**III**	18.31	**III**
Lack of proper infrastructural facilities	18.63	**III**	22.83	**I**	22.19	**II**	21.22	**II**
Lack of storage and processing facility	16.31	**IV**	14.75	**IV**	13.98	**IV**	15.01	**IV**
Education Constraints								
Lack of basic knowledge about PHM practices	11.28	**II**	15.38	**I**	14.25	**I**	13.64	**I**
Lack of mass media exposure on this topic	9.24	**IV**	10.84	**II**	10.52	**II**	10.20	**II**
Lack of prior experience	8.61	**V**	7.92	**III**	8.66	**IV**	8.40	**IV**
Lack of willingness to take initiative	10.65	**III**	7.42	**IV**	8.75	**III**	8.94	**III**
Lack of motivation and skill about proper production	11.59	**I**	6.52	**V**	6.79	**V**	8.30	**V**
Number of observation	**120**		**120**		**120**		**360**	
Kendall's W	**0.27**		**0.45**		**0.55**		**0.38**	
Chi-square	**901.9**		**1473.1**		**1780.4**		**3706.7**	
df.	**27**		**27**		**27**		**27**	

Source: Field Survey, 2022-23

Table 4.56 shows the production, marketing, economic, education, financial, technical, and infrastructure restrictions experienced by farmers in the research region while marketing cabbage crops. Kendall's W was determined to be 0.27, 0.45, and 0.55 for the districts of Solan, Mandi, and Shimla, respectively, and the asymptotic significance was 0.000, which is significant ($p<0.01$). In place of the null hypothesis, the alternative hypothesis, according to which farmers encounter identical challenges when, marketing their cabbage crops, was adopted. Overall, Kendall's W value of 0.38 suggests that there was 38% agreement among the farmers in rating the limitations.

A study was carried out to explore the production-related constraints faced by cabbage farmers in the study region. The most important constraint in the Solan district was the shortage of labor on time, with a mean score of 14.93 (rank I), followed by a scarcity of high yielding variety seed and a lack of market knowledge, with mean ratings of 14.51 and 12.17 (rank II and III), respectively. Similarly, with a mean score of 12.45, a lack of irrigation facilities was a major repression (rank I) in Mandi district, followed by a scarcity of high yielding variety seed. The most major issue faced by cabbage producers in the Shimla area, however, was lack of high-yielding variety seed, with a mean score of 11.34. Overall, non-availability of high yielding variety seed (12.19) and non-availability of labor on time (10.85) were identified as two key production constraints faced by cabbage producers in the research region.

Farmers' most difficult task is marketing perishable and seasonal crops. The previous table shows that the most significant barrier in marketing cabbage crops experienced by the selected farmers was the variation of marketing prices in the districts of Solan, Mandi, and Shimla, with mean scores of 22.10, 24.25, and 25.60. According to the findings of the survey, the second-most significant marketing limitation encountered by cabbage producers was market distance from the field area, with a mean score of 21.33, followed by a long chain of intermediaries, with a mean score of 20.90.

Individuals' livelihoods were being affected by financial restraints. The above table shows that among of the financial restrictions faced by the sampled farmers, the most severe difficulty was the high cost of pesticides and fertilizers, with mean scores of 18.89 in Solan, 16.13 in Mandi, and 19.52 in Shimla, respectively. The survey also found that farmers received lower prices for their goods during marketing, which was the second limitation experienced by Solan farmers and ranked fourth in Mandi and Shimla district. Minor financial restrictions experienced by farmers in the research region included non-availability of loan on time (rank VIII) and a long payback period in investment (rank VII), with mean scores of 8.81 and 10.77. Rohit *et al.* (2017) also found that high cost of fertilizers and manure was major financial constraint faced by the farmers.

The preceding table showed that the top technological and infrastructural restriction experienced by the respondents from the Solan and Shimla districts, with mean scores of 21.49 and 25.65, was the lack of information regarding vegetable production and marketing that could be found online or by SMS. Similarly, the farmers in the Mandi area, with a mean score of 22.83, felt that the main issue was a lack of adequate infrastructure (rank I).Overall, these two constraints were the important technical constraints faced by the farmers of study area followed by Lack of training on post-harvest handling practices and technologies (rank III) and Lack of processing facility (rank IV).

The most significant educational barrier faced by farmers was a lack of basic knowledge of post-harvest management procedures, which was rated first with a mean score of 15.38 in Mandi and 14.25 in Shimla. This was followed by a lack of exposure to this issue in the media. In Solan, on the other hand, rank I was attributed to a lack of motivation and skill for proper production, with a mean score of 11.59. Rank II was attributed to a lack of fundamental understanding of post-harvest management methods, with a mean score of 11.28. Overall, the sampled farmers' minor educational constraints were a lack of ambition and knowledge about how to produce cabbage properly, which placed them in fifth place in the research region with a mean score of 8.30. Cabbage farmers have significant challenges due to low educational attainment, which hinders their capacity to embrace novel technology and results in inadequate scientific and technical knowledge.

4.10.3 Constraints faced by the farmers for marketing of Green Pea crops in the study area

The study examines the obstacles faced by green pea growers in the area under research, and the results are arranged using the Kendall W approach in descending order.

When it comes to causing a high range of losses in green pea crop marketing, the constraint with the greatest mean value is considered to be the most important.

Table 4.57 Problem faced by the farmers in marketing of Green Pea crop in study area

Constraints	Green Pea							
	Solan		Mandi		Shimla		Overall	
	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank
Production constraints								
Non availability of planting material on time	10.65	**V**	6.07	**V**	6.86	**V**	7.86	**V**
Non availability of high yielding variety seed	14.76	**I**	9.85	**III**	7.44	**IV**	10.68	**II**
Non availability of market information	14.31	**II**	10.67	**II**	11.41	**I**	12.13	**I**
Lack of irrigation facilities	12.37	**III**	9.81	**IV**	9.69	**II**	10.62	**III**
Non availability of labor on time	10.86	**IV**	12.36	**I**	8.07	**III**	10.43	**IV**
Marketing Constraints								
Lack of transportation	18.44	**III**	19.41	**V**	18.86	**IV**	18.90	**IV**
Fluctuation in marketing prices	19.89	**II**	21.42	**II**	22.99	**III**	21.43	**II**
Absence of regulated market	10.63	**VI**	19.97	**IV**	16.45	**V**	15.68	**VI**
Distant market	14.03	**V**	18.61	**VI**	16.36	**VI**	16.33	**V**
Lacking in grading and packaging	18.21	**IV**	20.88	**III**	23.14	**II**	20.74	**III**
Long chain of intermediaries	22.13	**I**	23.76	**I**	25.76	**I**	23.88	**I**
Financial Constraints								
High cost of planting material	8.83	**VIII**	9.84	**VIII**	7.81	**VIII**	8.83	**VIII**
High cost of pesticides and fertilizers	16.37	**III**	15.47	**II**	16.30	**III**	16.04	**II**
High cost of labor	18.55	**I**	16.30	**I**	19.59	**I**	18.15	**I**
Non-availability of credit in time	16.00	**IV**	14.76	**III**	17.20	**II**	15.99	**III**
Low prices of the produce	17.72	**II**	14.68	**IV**	13.49	**IV**	15.30	**IV**

High initial investment on infrastructure	11.46	**VI**	13.16	**V**	12.87	**V**	12.50	**VI**
High payback period in investment	9.92	**VII**	11.17	**VI**	11.10	**VII**	10.73	**VII**
Unawareness of insurance facilities in case of risk	13.80	**V**	12.00	**VII**	11.80	**VI**	12.53	**V**
Technical and Infrastructural								
Lack of storage and processing facility	21.60	**I**	22.33	**II**	25.68	**I**	23.20	**I**
Lack of training on postharvest handling practices and technologies	19.36	**II**	17.22	**III**	18.17	**III**	18.25	**III**
Lack of proper infrastructural facilities	19.13	**III**	22.78	**I**	22.28	**II**	21.39	**II**
Non availability of vegetable growing and marketing related information through SMS/Internet	16.46	**IV**	15.01	**IV**	13.81	**IV**	15.09	**IV**
Education Constraints								
Lack of basic knowledge about PHM practices	10.65	**II**	15.78	**I**	14.08	**I**	13.50	**I**
Lack of mass media exposure on this topic	9.25	**IV**	10.44	**II**	10.59	**II**	10.09	**II**
Lack of prior experience	8.68	**V**	8.30	**III**	8.72	**IV**	8.56	**IV**
Lack of willingness to take initiative	10.59	**III**	7.22	**IV**	8.79	**III**	8.86	**III**
Lack of motivation and skill about proper production	11.39	**I**	6.75	**V**	6.68	**V**	8.27	**V**
Number of observation	**120**		**120**		**120**		**360**	
Kendall's W	**0.27**		**0.45**		**0.55**		**0.38**	
Chi-square	**896**		**1462**		**1805.7**		**3721.6**	
df.	**27**		**27**		**27**		**27**	

Source: Field Survey, 2022-23

Table 4.57 illustrates the limitations on production, marketing, economics, education, finance, technology, and infrastructure that farmers in the research region had to deal with while selling their green pea crops. Kendall's W was determined to be 0.27, 0.45, and 0.55 for the districts of Solan, Mandi, and Shimla, respectively, with an asymptotic significance of 0.000 ($p<0.01$). The alternate hypothesis, which claimed that farmers faced agreement-based restrictions in selling their green pea crops, was accepted in place of the null hypothesis. Overall, Kendall's W value of 0.38 suggests that there was 38 per cent agreement among the farmers in evaluating the constraints that they faced.

The study analyzed the production constraints faced by green pea producers in a specific region. The main obstacle faced by green pea growers in the Solan district was the lack of high-yielding variety seed, with a mean score of 14.76 (rank I). This was followed by the lack of market information and irrigation facilities, with mean scores of 14.31 and 12.37 (rank II and III), respectively. Comparably, in the Mandi district, the inability to acquire labor on time (rank I) had a mean score of 12.36, while the lack of market information (rank II) had a mean score of 10.67. However, lack of market knowledge was the biggest problem green pea producers in the Shimla district faced, with a mean score of 11.41. Overall, the research revealed that the two main production barriers faced by the green pea producers in the study region were the lack of market knowledge (12.13) and high yielding variety seed (10.68).

Farmers in the Solan, Mandi, and Shimla district face significant challenges in marketing perishable produce. The above table also revealed that marketing constraints in the Solan, Mandi and Shimla district long chain of intermediaries (rank I) with the mean score 22.13, 23.76 and 25.76 was the major problem faced by the sampled farmers in the marketing of green pea crops. In the study area, most green pea crops were marketed through regional traders and intermediaries, who receive a fee, resulting in lower prices for farmers. At overall level, the main problems farmers faced during marketing of green pea crop were fluctuation in marketing prices (rank II) with the mean score 21.43 followed by lacking in grading and packaging placed in third position with mean 20.74.

The above table also indicated that the main challenge faced by the investigated farmers in the selling of green pea crops in the Solan, Mandi, and Shimla districts was a long chain of intermediaries, which placed on top position with mean scores of 22.13, 23.76, and

25.76. Most green pea crops in the study area were marketed through regional traders and middlemen, who were paid a fee, resulting in lower prices for farmers. With a mean score of 21.43, fluctuating marketing prices were the most significant issue farmers faced overall while marketing green pea crops, followed by poor grading and packaging in third place with a mean score of 20.74.

The financial constraints that farmers faced were affecting their livelihoods. The table above showed that the most severe challenge faced by the sampled farmers in the study area was the high cost of labor, with mean scores of 18.55 in Solan, 16.30 in Mandi, and 19.59 in Shimla. The second major financial constraint that farmers faced in marketing green pea was low produce prices in Solan, with a mean score of 17.72; the high cost of pesticides and fertilizers in Mandi, with a mean score of 15.47; and the inability to acquire credit in sufficient time in the Shimla district, with a mean score of 17.20. The study came to the conclusion that the farmers' minor obstacles in marketing green pea crops were the high cost of planting materials and the extended return period for investments.

The technical and infrastructure restrictions that the green pea producer has while marketing their crop were also shown in the above table. Based on the survey, the respondents from the Solan and Shimla districts, with mean scores of 21.60 and 25.68, said that the main technological and infrastructural barrier they faced was lack of and storage processing facility. Similarly, the sampled farmers in the Mandi area identified inadequate infrastructure as their top concern, with a mean score of 22.78. Overall, these two constraints were the important technical constraints faced by the farmers of study area followed by lack of training on post-harvest handling practices and technologies (rank III) and non-availability of vegetable growing and marketing related information through Internet/SMS (rank IV) with the mean score 18.25 and 15.09.

The most significant education obstacles reported by farmers were a lack of fundamental understanding of post-harvest management procedures, which rated highest with a mean score of 15.78 in Mandi and 14.08 in Shimla, followed by lack of mass media exposure on this issue. In Solan, the major problem came across by green pea producers was a lack of motivation and expertise in proper production, with a mean score of 11.39, followed by a lack of fundamental knowledge of post-harvest management measures, with a mean score of 10.65. Overall, the least significant education restriction experienced by the sampled farmers was a lack of enthusiasm and skills in optimal green pea production, which ranked fifth in the research region with a mean score of 8.27. Lack of education places a significant burden for cabbage farmers, reducing their capacity to absorb new technologies and leading to inaccurate scientific and technical understanding.

4.11 Farmers suggestion for managing the post-harvest losses of selected vegetable crops in the study area

Vegetables require a significantly more advanced marketing plan due to the perishable nature of fresh food. The following tables show the distribution of sampled farmers according to their suggestions to mitigate the post-harvest losses of selected vegetable crops in the selected districts of Himachal Pradesh. They were requested to provide appropriate, useful suggestions for handling the post-harvest losses of selected vegetable crops. These suggestive measures were analyzed through Relative Importance Index (RII), rank analysis and the feedback of sampled farmers was received on a (1-5) Likert scale. The RII value ranges from 0 to 1with 0 not inclusive. It shows that higher the value of RII, more important was the sustainable criteria and vice versa.

4.11.1 Suggestion for managing post-harvest losses during marketing of Tomato crops

The distribution of farmers by their suggestions for reducing post-harvest losses of tomato crop in selected district of Himachal Pradesh is presented in table 4.58. Rank analysis was used to evaluate the different recommendations made by the sampled farmers. According to the above table, the Solan district's sampled farmers demand efficient market information in order to sell their goods at the right time and place for the best return (rank first) because better information about the market helps farmers to closely match their production to market demand and timing of their harvest for maximum profit, whereas this suggestion ranked third in Mandi and Shimla, followed by management of pre-harvest production practices rank second because the post-harvest shelf life is significantly impacted by pre-harvest procedures whereas in Mandi this suggestion was ranked fifth and the farmers of Shimla district ranked this suggestion in second position. Training on new technologies and market strategies was ranked third by sampled respondents of Solan district. In contrast, Mandi farmers placed this suggestion in second and farmers of Shimla district ranked it fourth. Whereas, for reducing post-harvest losses in tomato crop careful handling during harvesting, transportation and storage ranked fourth in Solan district but in Mandi and Shimla district this suggestion was ranked first by the sampled farmers. At last, proper packaging with proper labeling ranked fifth in both Solan and Shimla district but the farmers of Mandi district ranked it fourth.

Table 4.58 Farmers suggestions for reducing post-harvest losses of Tomato crop produce

Tomato									
Sr. no.	Suggestive Measures	Solan		Mandi		Shimla		Overall	
		RII	Rank	RII	Rank	RII	Rank	RII	Rank
1	Careful handling during harvesting, transportation and storage	0.86	IV	0.90	I	0.92	I	0.89	III
2	Harvesting at maturity stage	0.84	VI	0.86	VII	0.81	VII	0.86	V
3	Provide storage facilities	0.80	VII	0.88	VI	0.84	VI	0.84	VI
4	Proper packaging with proper labeling	0.85	V	0.89	IV	0.86	V	0.52	VII
5	Management of pre-harvest production practices	0.87	II	0.88	V	0.90	II	0.88	IV
6	Provide effective market information	0.89	I	0.91	III	0.89	III	0.90	I
7	Training on new technologies and market strategies	0.87	III	0.93	II	0.89	IV	0.90	II

Source: Field Survey, 2022-23

Overall, the suggestion has been grouped according to the relative importance index value range (Table 3.10). The above table 4.58 revealed that the following suggestion by the farmers of study area i.e. provides effective market information (0.90), training on new technologies and market strategies (0.90), careful handling during harvesting, transportation and storage (0.89), management of pre-harvest production practices (0.88), harvesting at maturity stage (0.86), provide storage facilities (0.84) has high importance level except proper packaging with proper labeling (0.52) which has medium importance level.

4.11.2 Suggestion for managing post-harvest losses during marketing of Cabbage crops

Table 4.59 Farmers suggestions for reducing post-harvest losses of Cabbage crop produce

Cabbage									
Sr. no.	Suggestive Measures	Solan		Mandi		Shimla		Overall	
		RII	Rank	RII	Rank	RII	Rank	RII	Rank
1	Careful handling during harvesting, transportation and storage	0.84	III	0.82	VI	0.85	V	0.84	V
2	Harvesting at maturity stage	0.81	VII	0.81	VII	0.84	VI	0.82	VII
3	Provide storage facilities	0.81	VI	0.82	V	0.84	VII	0.82	VI
4	Proper packaging with proper labeling	0.82	V	0.86	III	0.89	III	0.85	IV
5	Management of pre-harvest production practices	0.86	I	0.85	IV	0.89	IV	0.86	III
6	Provide effective market information	0.85	II	0.90	II	0.89	II	0.88	II
7	Training on new technologies and market strategies	0.84	IV	0.92	I	0.91	I	0.89	I

Source: Field Survey, 2022-23

Table 4.59 shows the farmers recommendations for minimizing post-harvest losses of the cabbage crop in selected district of Himachal Pradesh. The data presented in the above table indicates that, in order to increase the shelf life of the cabbage crop, farmers in the Solan district recommended management of pre-harvest production techniques which ranked first. However, respondents from the Mandi and Shimla districts ranked this suggestion in fourth place, while the suggestion for training in new technological skills was ranked first and fourth in Solan district. Further, the study resulted that in the selected district an effective knowledge of market would reduce the post-harvest losses which was ranked in second position, followed by proper packaging of produce that reduces the damages and injury occur during loading, unloading was ranked in third.

Overall, the recommendation has been arranged based on its relative importance index value range (Table 3.10). The 4.52 showed that each recommendation made by the farmers for reducing post-harvest losses in the study area such as, providing valuable market information (0.88), training on new technologies and market strategies (0.89), handling carefully during harvesting, transportation, and storage (0.84), managing pre-harvest production practices (0.86), harvesting at the maturity stage (0.82), and providing storage facilities (0.82) and proper packaging with proper labeling of cabbage crop (0.85) had a high importance level. The study came to the conclusion that every recommendation made by the farmers was significant in minimizing the post-harvest losses of the cabbage crop.

4.11.3 Suggestion for managing post-harvest losses during marketing of Green Pea crops

Table 4.60 Farmers suggestions for reducing post-harvest losses of green pea crop produce

Green Pea									
Sr. no.	**Suggestive Measures**	**Solan**		**Mandi**		**Shimla**		**Overall**	
		RII	**Rank**	**RII**	**Rank**	**RII**	**Rank**	**RII**	**Rank**
1	Careful handling during harvesting, transportation and storage	0.82	III	0.84	V	0.81	V	0.82	V
2	Harvesting at maturity stage	0.79	V	0.83	VII	0.80	VI	0.81	VI
3	Provide storage facilities	0.76	VII	0.83	VI	0.77	VII	0.79	VII
4	Proper packaging with proper labeling	0.79	VI	0.87	III	0.82	IV	0.82	IV
5	Management of pre-harvest production practices	0.83	II	0.86	IV	0.86	III	0.85	III
6	Provide effective market information	0.84	I	0.88	I	0.89	II	0.87	I
7	Training on new technologies and market strategies	0.81	IV	0.87	II	0.92	I	0.87	II

Source: Field Survey, 2022-23

Table 4.60 presents the suggestions proposed by farmers in a selected district of Himachal Pradesh for reducing post-harvest losses of the cabbage crop. Farmers in the districts of Solan and Mandi stated that, out of all the recommendations, effective market information ranked highest, while in the district of Shimla, it came in second position. The study further revealed that in Solan district the respondents also suggested to manage the pre-harvest production practices (rank second) followed by careful handling of green peas during harvesting, transportation and storage (rank third), provide trainings on new technologies and market strategies (rank fourth), harvesting at proper matured stage of green pea crop (rank fifth). Whereas, training programme on new technologies and effective market strategies placed rank II in Mandi district and rank I in Shimla district, followed by proper packaging of produce during transportation (rank III), Management of pre-harvest production practices (rank IV), careful handling during harvesting, transportation and storage (rank V). The table also resulted that among the various recommendation made by the sampled farmers, management of pre-harvest production practices was ranked in third position followed by good packaging of the produce, careful handling during harvesting, transportation and storage, harvesting at maturity stage and availability of storage facility suggestion ranked last by the farmers of Shimla district.

Overall, the relative importance index value range has been utilized for classifying the suggestions overall (Table 3.10). According to the above table 4.53, the following recommendations made by the farmers in the study area—providing efficient market information (0.87), training on new technologies and market strategies (0.87), managing pre-harvest production practices (0.85), proper packaging with proper labeling (0.82), carefully handling during harvesting, transportation, and storage (0.82) and harvesting at the maturity stage (0.81)—have a high importance level, with the exception of Provide storage facilities (0.79), which vary from high to medium importance level. The study revealed that almost each suggestion offered by farmers was extremely important for decreasing post-harvest losses of green pea crops.

Chapter-5

SUMMARY AND CONCLUSION

This chapter includes an overview of the present investigation as well as the key findings. This chapter also includes policy implications that have been presented based on findings from the data analysis.

5.1 INTRODUCTION

Himachal Pradesh's agricultural output has increased significantly, leading to increased productivity and production of grain crops used for food and non-food purposes. A quarter of the state's GDP is generated by the agriculture industry. The agricultural community, including 8.63 lakh farmers, of which 84.5% are small and marginal farmers, owns 9.99 lakh hectares (Statistical Abstract of Himachal Pradesh, 2022).In the years 2021–2022, Himachal Pradesh planted 90.94 thousand hectares of vegetables. The state produced 19.36 lakh tons of vegetables, with an average yield of 21.29 tonnes per hectare (Anonymous, 2022).

Producing vegetables requires a lot of labor, takes little time, and is more profitable, thus it works well in marginal and small farm production systems (Bindra *et al.* 2010). Despite excellent output, one of the key causes of low performance is post-harvest losses across the state. After harvest, vegetables incur large losses ranging from 15% to 50% due to inadequate handling in storage, shipping, packaging, and processing, which is one of the key sources of concern (Roy, 1989; Kiaya, 2014; Kaur and Khurana, 2021; Verma and Singh, 2004). Approximately 40% of fruits and vegetables were lost each year due to improper storage, transportation, and packing, among other factors (Singh *et al*., 2014).

Vegetables face high metabolic activities and short shelflife, leading to significant post-harvest losses. Reducing these losses can increase vegetable supply and reduce transportation and marketing costs. These losses occur at various stages of production, including handling, storage, packaging, and distribution. Proper post-harvest intervention can help reduce these losses, benefiting both producers and consumers. The reduction in lots can also increase vegetable production.Vegetable post-harvest losses can be evaluated to determine the causes and extent of these losses. It also helps in the development of strategies to stop or lessen losses, increasing the availability of particular vegetables for both local and international use.

Effective post-harvest management of vegetable crops leads to increased yields and revenues for growers, emphasizing the need for equal attention to post-harvest practices as production practices. So, this study aims to analyze post-harvest losses during marketing of selected vegetable crops.

5.2 OBJECTIVES

1. To study the existing status of post-harvest losses during marketing of selected vegetable crops.
2. To identify factors affecting post-harvest losses of farmers' during marketing of vegetable crops.
3. To identify the key constraints and suggest management interventions for managing post-harvest losses during marketing of vegetable crops.

5.3 METHODOLOGY

The present investigation was conducted in Himachal Pradesh to investigate the post-harvest losses during marketing of selected vegetable crops.

The study used a multi-stage random sampling procedure for the selection of sample respondents of Himachal Pradesh. A total of three districts selected for the study namely Solan, Shimla and Mandi. Furthermore, three blocks from each district were selected. These blocks were purposely selected as tomato cultivation covers the larger production in these blocks. Four villages were selected from each block randomly. At last 10 farmers from each village were selected randomly.

The sample size for the present research was calculated using the pilot survey from the study. To calculate the sample size, the Krejcie and Morgan (1970) method were also used. Thus, a total of 360 vegetable growers constitute the sample. A scheduled and pre-tested questionnaire was employed to gather information from tomato producers, following consultation with specialists. Basic mathematical procedures, including measures such as the mean, percentage, and frequency distribution, were used to fulfill the research purpose. To achieve the first objective, compound annual growth rate and percentage method were used to know the existing status of post-harvest losses, whereas to achieve second objective identify the factor that affect post-harvest vegetable crops Ordered probit regression method were used. Also, for identification of the factors that were implemented by famers to manage the post-harvest losses Principal component analysis (PCA) was used. Kendall W methods was used to identify the constraints faced by farmers for managing post-harvest losses and to identify the suggestive intervention for managing post-harvest losses during marketing of selected vegetable crops relative importance index method was used.

5.4 MAJOR FINDINGS

The key findings from this study are presented below:

1. Despite a significant rise in tomato output (2.75%) and area (3.78%) annually, the state's overall productivity fell by 1.0 percent. On the other hand, the area planted to cabbage has been growing by 0.9% per year. Yield per hectare of farmed land has been declining by around 0.67 percent despite increases in area and output (0.23%). The green pea crop showed a slight increase of 0.1% in area, but an impressive 2.55% increase in production during the given time period indicates steady growth with a slight improvement in productivity (1.07%).

2. The study's findings showed that while cabbage post-harvest losses decreased from 102.14 to 89.64 quintals over the span of the previous three years, tomato post-harvest losses increased dramatically to 262.25 quintals. The amount of green peas lost varied, beginning with a loss in at 14.76 quintals, then falling to 130.65, and finally rising little to 136.58 quintals by 2022–2023, demonstrating dynamic patterns in crop protection.

3. The data revealed from the study that Solan district was the top contributor to tomato production, followed by Shimla and Mandi, resulting in a total of 3010 quintals. Shimla leads in cabbage production, followed by Mandi and Solan, resulting in 1745 quintals. Shimla also leads in green pea production, with 828 quintals, followed by Mandi and Solan, resulting in 2214 quintals.

4. The data showed that post-harvest losses for the green pea, tomato, and cabbage crops in Shimla, Mandi, and Solan vary. The fact that Shimla continuously suffers the most losses highlights the difficulties with handling, shipping, and supply chain management in general. Lower losses were seen in Mandi and Solan, suggesting the possibility for focused treatments. The importance of handling and transportation concerns in lowering total post-harvest losses and advancing agricultural sustainability has been highlighted by persistent trends across all crops.

5. According to the survey, farmers in Himachal Pradesh experience difficulty while cultivating tomatoes, cabbage, and green peas. Pests, diseases, and market challenges are the most common concerns for tomatoes. Cabbage producers, particularly in Solan, face environmental and marketing-related challenges. Green pea harvests in all areas are affected by both environmental conditions and marketing issues. To address these issues and decrease crop losses, farmers in the region must implement a comprehensive plan that includes pest and disease management, environmental adaptation, and improved marketing methods.

6. The survey shows that 35% of vegetable farmers experienced low losses, while 65% experienced moderate losses between 5-25%. None reported high losses exceeding 25%. This suggests the need for improved post-harvest management practices and targeted interventions to minimize losses in vegetable crops, enhancing overall crop preservation techniques.

7. Several significant factors were identified through the regression analysis of post-harvest losses in tomato, cabbage, and green pea crops in the study area. Post-harvest handling training, harvest time, distance to market, time of sale, type of packaging, harvest method, storage facility, and access to market information were found to have a significant impact on losses in tomato, cabbage, and green pea crops, according to ordered probit estimates. The model's explanatory power was demonstrated by pseudo R-squared values of 0.34, 0.39, and 0.29 for tomato, cabbage, and green pea crops, respectively. Post-harvest losses in various crops were also affected by characteristics such as age, education, harvesting methods, family size, farming experience, and landholding capacity. Post-harvest handling training was essential for preventing losses in vegetable crops. Access to market information can also help in reduction of tomato and green pea losses. Harvest timing, transportation distance, and storage facilities all have an influence on crop losses.

8. The study further examined farm management strategies for tomato, cabbage, and green pea crops, revealing five critical components for reducing post-harvest loss. The first component, which included removing diseased produce, pre-cooling, and pest-disease treatments, accounted for 18.42% of tomato variability. In cabbage and green peas, it accounted for 15.16% and 15.87%, respectively. Subsequent components highlighted additional critical practices, contributing to cumulative variability of 70.27%, 65.44%, and 67.35%. Significant correlations were found as crucial indicators of farmers' adoption behaviors.

9. Farmers predominantly turn to informal sources like neighbors and social media (83.1%) to mitigate post-harvest losses in vegetable crops, showcasing a preference for community-driven knowledge sharing. Government-sponsored seminars (65.6%) also play a significant role, highlighting the significance of authorized channels. The decline in dependence on traditional newspapers and other media signifies an evolution towards increasingly engagement and specialized information-seeking behavior.

10. Farmers in the study area face challenges in production, marketing, economics, education, financial, technical, and infrastructure aspects of cultivating tomato, cabbage, and green pea crops. Issues include non-availability of high-yielding seeds, long marketing chains, high pesticide and fertilizer costs, lack of storage and processing facilities, and insufficient knowledge about post-harvest management practices. The findings emphasize the need for comprehensive support and interventions to enhance the agricultural ecosystem.

11. A thorough investigation conducted in Solan, Mandi, and Shimla districts in Himachal Pradesh highlights the complex methods that farmers employ for reducing post-harvest losses for tomato, cabbage, and green pea crops. Solan highlights the obtaining of market information for tomatoes and the implementation of pre-harvest methods for cabbage. However, it focuses significance on the careful handling and pre-harvest procedures for green peas. Mandi prioritises technological training for the cultivation of tomatoes and green peas, whereas Shimla places importance on providing market insights and efficient packaging methods for cabbage and green peas. In summary, the results illustrate the importance of developed and location-specific strategies to reduce post-harvest losses in different agricultural environments.

CONCLUSION

It was observed from the study that, overall the agriculture sector in Himachal Pradesh exhibits challenges and future potential. Although tomato output has improved, there is a significant decline in productivity, while cabbage and green peas exhibit inconsistent patterns. Solan district led in tomato production, followed by Shimla and Mandi, with 3010 quintals. The study revealed that cabbage post-harvest losses decreased, while tomato losses increased significantly to 262.25 quintals. Green pea losses varied, starting at 14.76 quintals and decreasing to 130.65 quintals by 2022-2023.

The findings of the study, respondents' age and education level have no significant influence on post-harvest losses in chosen vegetables. However, family size is positively connected with green pea and cabbage losses, but farming experience has a strong negative connection with cabbage losses, showing that experienced farmers may better handle post-harvest problems. Post-harvest losses vary across crops and districts, with handling and transportation issues contributing to the complexities. Farmers in Himachal Pradesh face pests and market challenges, resulting in moderate losses. To address these issues, targeted training and improved post-harvest practices are crucial. Informal knowledge-sharing through community channels and government seminars is vital. Obstacles related to high variety seeds, marketing, and gaps between knowledge and understanding highlight the necessity of all-inclusive assistance. Further suggested that modified approaches are required, taking consideration of the distinct qualities of every crop and region. Above all, maintaining agriculture in Himachal Pradesh and ensuring a profitable farming future depend on resolving post-harvest issues.

POLICY IMPLICATIONS

A comprehensive policy strategy is needed to address post-harvest losses during the marketing of green pea, tomato, and cabbage crops in Himachal Pradesh. At first in order to ensure the effective processing and transportation of crops, the government should place a high priority on infrastructure development. Investments in storage facilities, transportation networks, and market infrastructure should be made. Policies should also be implemented to increase market accessibility and give farmers timely access to market data so they may make enriched decisions. Incentives for implementing modern post-harvest technology can improve farmers' abilities and lower losses when combined with educational programmes and capacity-building projects. Tailoring techniques to the particular features of each crop, such as tomato, cabbage, and green peas, is vital for optimal post-harvest management. Enforcing quality control procedures is necessary to preserve the integrity of harvested commodities at every stage of the supply chain. Research and development programmes alongside with financial assistance for smallholder farmers can help them get beyond financial obstacles and encourage the development of innovative post-harvest techniques. In order to overcome post-harvest challenges, cooperation with agricultural extension services and the development of public-private partnerships enhance the dissemination of information and bring in additional resources. The overall goal of these modifications to policy is to minimize post-harvest losses and guarantee farmers' prosperity in Himachal Pradesh by promoting an adequate and sustainable agricultural environment.

LITERATURE CITED

Acharya S S and Agarwal N L. 2021. *Agricultural Marketing in India*. 7th ed. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi. 530p.

Ade A T and Bosede S J. 2016. Ordered probit analysis of factors influencing farmers' contributions to climate change adaptation decisions in Southwest Nigeria. *Trends in Agricultural Economics* **10**:1-11.

Affognon H C, Mutungi C, Sanginga P and Borgemeister C. 2015. Unpacking postharvest losses in Sub-Saharan Africa: A meta-analysis. *World Development* **66**:49-68.

Ahmad K, Afridi M, Khan N A and Sarwar A. 2021. Quality deterioration of postharvest fruits and vegetables in developing country Pakistan: A mini overview. *Asian Journal of Agriculture and Food Science* **9**:1571-2321.

Aidoo R, Rita A D and Mensah J O. 2014. Determinants of postharvest losses in tomato production in the Offinso North District of Ghana. *Journal of Development and Agricultural Economics* **6**:338-344.

Akpalu D A. 2013. Agriculture extension service delivery in a semi-arid rural area in South Africa: The case study of Thorndale in the Limpopo province. *African Journal of Food, Agriculture, Nutrition and Development* **13**:8034-57.

Alhaji H Y. 2010. Determining sufficiency of sample size in management survey research activities. *International Journal of Organisational Management and Entrepreneurship Development* **6**:119-130.

Ali J. 2012. Factors influencing adoption of postharvest practices in vegetables. *International Journal of Vegetable Science* **18**:29–40.

Alidu A F, Ali E B and Aminu H. 2016. Determinants of post-harvest losses among tomato farmers in the Navrongo Municipality in the Upper East Region. *Journal of Biology, Agriculture and Healthcore* **6**:14-20.

Anonymous. 2023. *Economic Survey 2022-2023*. Department of Agriculture and Food Management (Government of India). *https://www.indiabudget.gov.in/economicsurvey/doc/eschapter/echap07.pdf.* (12:45AM, 13th February 2023).

Anonymous. 2023. Agricultural and Processed Food Products Export Development Authority (Government of India). *https://apeda.gov.in/apedawebsite/*. (1:03 AM, 17th May 2024).

Arah I K, Kumah E K, Anku E K and Amaglo H. 2015. An overview of post- harvest losses in tomato production in Africa: Cause and possible prevention strategies. *Journal of Biology, Agriculture and Healthcare* **5**:78-88.

Arah, Amaglo H, Kumah E K and Ofori H. 2015. Preharvest and postharvest factors affecting the quality and shelf life of harvested tomatoes. *International Journal of Agronomy* :1-6.

Arya S R S and Sahah S L. 1984. New technology of rainfed agriculture and identification of constraints on its adoption in mid hills of UP. *Agricultural situation in India* **39**:487-496.

Asayehegn K, Yirga C and Rajan S. 2011. Effect of small-scale irrigation on the income of rural farm households: The case of Laelay Maichew district of Central Tigray, Ethiopia. *Journal of Stored Products and Postharvest Research* **2**:43-57.

Asrat P and Simane B. 2018. Farmers' perception of climate change and adaptation strategies in the Dabus watershed, North-West Ethiopia. *Ecological Processes* **7**:1-13

Atanda S A, Pessu P O, Agoda S, Isong I U and Ikotun I. 2011. The concept and post-harvest food losses in perishable crops. *African Journal of Food Sciences* **5**:603-13.

Awan M S, Hussain A, Abbas T and Karim R. 2012. Assessment of production practices of small scale farm holders of tomato in Bagrote valley, CKNP region of Gilgit-Baltistan, Pakistan. *Acta Agriculturae Slovenica* **99**:191-199.

Baba S H, Wani M H, Wani S A and Yousuf S. 2010. Market surplus and price spread of vegetables in Kashmir valleys. *Agricultural Economics Research Review **23***:115-27.

Babalola D A, Makinde Y O, Omonona B T and Oyekanmi M O. 2010. Determinants of post- harvest losses in tomato production: A case study of Imeko – Afon local government area of Ogun state. *Journal of Life and Physical Sciences* **3**:14-18.

Bains S S and Atlas D K. 2022. Land utilization and cropping pattern in Himachal Pradesh. *International Journal of Trend in Scientific Research and Development* **6**:2456- 470.

Banjaw T D. 2017. Review of post-harvest loss of horticulture crops in Ethiopia, its causes and mitigation strategies. *Journal of Plant Sciences and Agricultural Research* **2**:1-4.

Bindra A D, Lal H, Chaudhary D R and Dubey Y P. 2010. Productivity and profitability of pea-summer squash cropping system regarding integrated nutrient management in high-hill cold dessert conditions. *Himachal Journal of Agricultural Research* **36**:149-154.

Boss R and Pradhan M. 2020. Post-harvest management and farm outcomes: Storage facilities matter. *Economic and Political Weekly* **55**:1-20.

Choudhary M and Bhati V. 2017. Constraints perceived by farmers in adoption of recommended production technology of mungbean in Jaipur district of Rajasthan. *International Journal of Current Microbiology and Applied Sciences* **6**:2107-114.

Choudhary M L. 2006. *Recent Developments in Reducing Postharvest Losses in the Asian-Pacific Region.* Ministry of Agriculturte, New Delhi. 22p.

Cossam F G, Dzanja J K, Kamwana B, Olumeh D E and Mithofer D. 2023. Determination of postharvest losses along the baobab value chain in Malawi. *Frontiers in Sustainable Food System* **7**:1-11.

Costales J A, Catulay J J E, Costales J A and Bermudez N P. 2022. Kaiser-Meyer-Olkin factor analysis: A quantitative approach on mobile gaming addiction using random forest classifier: 18-24.

Degebasa A C. 2020. Prospects and challenges of postharvest losses of potato in Ethiopia. *Global Journal of Nutrition and Food Science* **2**:1-10.

Department of Agriculture (DOA), Cooperation and Farmers' Welfare, Krishi Bhawan. 2021. *Annual Report 2020-2021*. New Delhi. 298p.

Department of Agriculture, Government of Himachal Pradesh. 2022. Project proposal for Transformation in Agriculture Using Emerging Technologies in the department of Agriculture– GoHP. *https://agriwelfare.gov.in/Documents/Proposal%20Of%20Himachal%20Pradesh.pdf.* (11:03 PM, 7th January 2023).

Department of Agriculture Himachal Pradesh. 2023. *Land Use Pattern*. *https://agriculture.hp.gov.in/en/land-use-pattern-english/* (1:18AM, 15th January 2024).

Department of Agriculture. 2009. *District Agriculture Plan*: Mandi, H.P., Vol. VIII. *https://hpbiodiversity.gov.in/Pdf/Agriculture%20plan%20Mandi.pdf.* (11:12 PM, 7th January, 2023).

Department of Agriculture. 2009. *District Agriculture Plan*: Solan, H.P., Vol. VIII. *https://hpbiodiversity.gov.in/Pdf/Agriculture%20plan%20Solan.pdf.* (11:12 PM, 7th January, 2023).

Department of Economic and Statistics. 2022. *Statistical Abstract of Himachal Pradesh.* Shimla.*https://himachalservices.nic.in/economics/pdf/State%20Statistical%20Abstract%20-%202021-22.pdf.* (1:12AM, 16th January 2024).

Devi N and Prasher R S. 2018. Growth pattern of vegetable crops in Himachal Pradesh. *International Journal of Agricultural and Statistical Sciences* **14**:5-13.

Dharmathilake N, Rosairo H, Ayoni V and Herath R M. 2020. Implications of post-harvest losses and acreage response of selected up-country vegetables from Nuwara-Eliya District in Sri Lanka on sustained food security. *The Journal of Agricultural Sciences-Sri Lanka* **15**:88-100.

Donagalska-Gredys M. 2020. Evaluation of dimensions of farmer's attitudes in Principal Component Analysis (PCA). *Annals of the Polish Association of Agricultural and Agribusiness Economists* **22**:66-76.

Dooga M Y, Agada P O and Ogwuche I O. 2021. Ordinal regression Assessment of orange Postharvest loss determinants among Orange Farmers in Konshisha Local Government Area of Benue State. *Nigeria Annals of Pure and Applied Sciences* **4**:1-13.

Duong N T. 2014. *Training Courses on Post-Harvest Technology in the Value Chain of Vegetables*. Institute of Agricultural Engineering and Post-harvest Technology, Vietnam. 80p.

Economic and Statistics Department Himachal Pradesh. 2023. *Economic Survey 2022-2023. https://himachalservices.nic.in/economics/pdf/economic_survey_2022-23.pdf.* (3:44 AM, 15th January 2024).

Food and Agriculture Organisation (FAO). 1980. *Assessment and collection of data on post-harvest foodgrain losses.* FAO Economic and Social Development Paper 13, Rome. 78p.

Food and Agriculture Organisation (FAO). 2019. Reducing post-harvest losses. *https://www.fao.org/3/ca6344en/ca6344en.pdf*. 2p.

Faqeerzada M A, Rahman A, Joshi R, Park E and Cho B K. 2018. Postharvest technologies for fruits and vegetables in South Asian countries: A review. *Korean Journal of Agricultural Science* **45**:325-53.

Figueroa M E, Kincaid D L, Rani M and Lewis G. (2002). *Communication for social change: An integrated model for measuring the process and its outcomes*. The communication for social change, Working Paper Series No. 1. The Rockefeller Foundation, New York. 50p.

Food and Agriculture Organisation (FAO). 2011. *Appropriate food packaging solutions for developing countries*. Save Food Interpack Congress held on 16 – 17 May 2011 in Dusseldorf, Germany, Rome. 35p.

Gajanana T M, Murthy S D and Sudha M. 2011. Post-harvest losses in fruits and vegetables in South India- A review of concepts and quantification of losses. *Indian Food Packer* **65**:178-87.

Gajanana T M, Murthy S, Sudha M and Dakshinamoorthy V. 2006. Marketing and estimation of post-harvest loss of tomato crop in Karnataka. *Indian Journal of Agricultural Marketing* **20**:1-11.

Gardas B B, Raut R D and Narkhede B. 2018. Evaluating critical causal factors for post-harvest losses in the fruit and vegetables supply chain in India using the DEMATEL approach. *Journal of Cleaner Production* **199**:47-61.

Garforth C, Khatiwada Y and Campbell D. 2003. Communication research to support knowledge interventions in agricultural development: Case studies from Eritrea and Uganda. Development Studies Association Conference, Glasgow, 10–12 Sept. 2003. 42p.

Garikai M. 2014. Assessment of vegetable postharvest losses among smallholder farmers in Umbumbulu area of Kwazulu-Natal Province, South Africa. M. Sc. Thesis. School of Agricultural, Earth and Environmental Sciences, College of Agriculture, Engineering & Science, University of KwaZulu-Natal, Pietermaritzburg. 137p.

Garrett E H and Woodworth R S. 1969. Statsistics in Psychology and Education. *Vakils, Feffer and Simons Pvt. Ltd., Bombay*. pp.329.

Gathambiri C W, Owino W O, Imathiu S and Mbaka J N. 2021. Postharvest losses of bulb onion in selected Sub-Countries of Kenya. *African Journal of Food, Agriculture, Nutrition and Development* **21**:17529-544.

Gautam P K and Jha S K. 2022. Socio-economic security in rural areas of Bundelkhand: A household level analysis. *Indian Research Journal of Extension Education* **22**:160-164.

Gautam S, Acedo A L, Schreinemachers P and Subedi B P. 2017. Volume and value of postharvest losses: The case of tomatoes in Nepal. *British Food Journal* **119**:2547-558.

Gearhart A, Booth D T, Sedivec K and Schauer C. 2013. Use of Kendall's coefficient of concordance to assess agreement among observers of very high resolution imagery. *Geocarto International* **28**:517-526.

Genova C, Weinberger K, Hoang B A, Dang D D, Nguyen T T L, Le N T and Nguyen T T T. 2006. Postharvest loss in the supply chain for vegetables - The case of chili and tomato in Vietnam. *http://www.avrdc.org/pdf.* (11.00 AM, 15thdecember 2023). 15p.

Ghanghas B S, Nain M S and Malik J S. 2017. Adoption of post-harvest management practices by vegetable growers in Haryana State. *Indian Journal of Extension Education* **53**:104-110.

Ghazal A F, El-Masry G M, El-Sheikh I H and Radwan S M. 2017. Estimation of some postharvest losses in tomato during simulated transport operation. *Misr Journal of Agricultural Engineering* **34**:291-216.

Greene W H (ed). 2003. *Econometric Analysis*. 5thed. New Jersey: Prentice Hall. 1056p.

Gujarati D N and Porter C D (eds). 2009. *Basic Econometrics*. 5thed. New York: McGraw-Hill. 946p.

Gupta B K and De D. 2011. Media possession and information source utilization pattern of rural women regarding child health care management. *Journal of Communication Studies* **29**:95-102.

Gupta S P. 2017. *Statistical Methods*. 46th ed. Sultan Chand & Sons, New Delhi. 1352p.

Harris S R. 1988. Production is only half the battle - A training manual in fresh produce marketing for the Eastern Caribbean, Food and Agrıculture Organization of the united Nations, Bridgetown, Barbados. 12p.

Hasan M U, Malik A U, Ali S, Imtiaz A, Munir A, Amjad W and Anwar R. 2019. Modern drying techniques in fruits and vegetables to overcome postharvest losses: A review. *Journal of Food Processing and Preservation* **43**:1-15.

Hazarika C. 2006. Post-harvest loss and food security: A study on fruits and vegetables in Assam. *Indian Journal of Agricultural Economics* **61**:418-419.

Hodges R J, Buzby J C and Bennett B. 2011. Postharvest losses and waste in developed and less developed countries: Opportunities to improve resource use. *Journal of Agricultural Science* **149**:37-45.

Jain P C. 2007. Handbook for new entrepreneurs. *Oxford University Press*, New Delhi. pp.338.

Jann B. 2005. Tabulation of multiple responses. *The Stata Journal* **5**:92–122

Jat J R, Singh S, Lal H and Choudhary L R. 2012. Constraints faced by Tomato growers in use of improved tomato production technology. *Rajasthan Society of Extension Education* **20**:159-163.

Kabir, S. M. S. 2016. Methods of Data Collection. In Basic Guidelines for Research: An introductory approach for all disciplines. Chap 9. Bangladesh: Book Zone Publication. pp. 201-275.

Kader A A. 2002. Postharvest technology of horticultural crops. 3rd ed. University of California Agriculture and Natural Resources, Oakland, Publ. pp. 3311.

Kader A A. 2005. Increasing food availability by reducing postharvest losses of fresh produce. *Acta Horticulturae* **682**:2169-175.

Kahramanoglu I, Rengasamy K R R, Usanmaz S, Alas T, Helvacı M, Okatan V, Aşkın M A and Wan C. 2021. Improving the safety and security of fruits and vegetables during COVID-19 pandemic with postharvest handling. *https://doi.org/10.1080/10408398.2021.1935703* (5:17PM, 21st February 2022). 21p.

Kalidas K and Akila K. 2014. Micro level investigation of marketing and post-harvest losses of tomato in Coimbatore district of Tamilnadu. *Journal of Stored Products and Postharvest Research* **5**:1-8.

Kalusopa T. 2005. The challenges of utilizing information communicationtechnologies (ICTs) for the small-scale farmers in Zambia. *Library hi tech* **23**:414-424.

Kaniki A M. 2001. Community profiling and needs assessment. In Stilwell C, Leach A and Burton S. (eds). *Knowledge, information and development: An African perspective.* Pietermaritzburg: University of KwaZulu-Natal. pp. 187-199.

Kaur I and Khurana K R. 2021. Determinants of post-harvest losses in fruits and vegetables: An empirical study of Punjab. *Turkish online journal of qualitative inquiry* **12**:3619-629.

Kereth G A, Lyimo M, Mbwana H A, Mongi R J and Ruhembe C C. 2013. Assessment of post-harvest handling practices: Knowledge and losses of fruits in Bagamoyo district of Tanzania. *Food Science and Quality Management* **11**:8-15.

Khaleel T and Nassar Y. 2018. Identification and analysis of factors affecting labour productivity in Iraq. *MATEC Web of Conferences.* Building and Construction Engineering Department, University of Technology, Baghdad, Iraq**162**:1-11.

Khatum M and Rahman M S. 2018. Quantifying postharvest losses of Tomato: A farm level study in selected area of Bangladesh. *The Bangladesh Development Studies* **41**:141-55.

Kiaya V. 2014. *Post-Harvest Losses and Strategies to reduce them.* Technical paper. Scientific & Technical Department. 25p.

Kikulwe E M, Okurut S, Ajambo S, Nowakunda K, Stoian D and Naziri D. 2018. Postharvest losses and their determinants: A challenge to creating a sustainable cooking Banana value chain in Uganda. *Sustainability* **10**:2381-400.

Kitinoja L, Saran S, Roy S K and Kader A A. 2011. Postharvest technology for developing countries: Challenges and opportunities in research, outreach and advocacy. *Journal Science of Food and Agriculture* **91**:597-603.

Kothari C R. 2005. *Research Methodology*. 2nd ed. New Age International Ltd., New Delhi. 418p.

Koundinya A, Palashsidhya and Pandit M K. 2014. Impact of climate change on vegetable cultivation- A review. *International Journal of Agriculture Environment and Biotech*nology **7**:145-155.

Kramchote S, Srilaong V, Wongs-Aree C and Kanlayanarat S. 2012. Low temperature storage maintains postharvest quantity of cabbage in supply chain. *International Food Research Journal* **19**:759-73.

Krejcie R V and Morgan D W.1970. Determining sample size for research activities. *Educational and Psychological Measurement* **30**:607-610.

Kumar A, SumitYadav M K and Rohila A K. 2019. Constraints faced by the farmers in production of and marketing of vegetables in Haryana. *Indian Journal of Agricultural Sciences* **89**:153-60.

Kumar D K, Basavaraja H and Mahajanshetti S B. 2006. An economic analysis of post-harvest losses in vegetables in Karnataka. *Indian Journal of Agricultural Economics* **61**:134-146.

Kumari M, Bairwa S L, Meena L K and Rahman S M. 2016. Availability and post-harvest losses of fruits and vegetables in Bihar: Economic analysis. *International Journal of Agricultural Invention* **1**:207-12.

Kumari M, Bairwan S L and Singh R G. 2015. An economic analysis of demand, supply prospects and post-harvest losses of major fruits and vegetables in Bihar. *Annals of Agri-Bio Research* **20**:235-40.

Kwame A E, Zhiguang Q, Ahudey E and Clement A P. 2020. Kendall's Coefficient of Concordance Ranking of the Effectiveness of Single Machine Learning Models in Predicting Stock Price Movement. *International Journal of Engineering Research & Technology (IJERT)* **9**:1098-1107

Kyei K and Matsui K. 2019. Assessing fruit farmers' perception of post-harvest losses in the Ashanti Region of Ghana. *International Journal of Environmental and Agriculture Research* **5**:1-5.

Lavassani K M, Movahed B, Kumar V. 2009. Developments in analysis of multiple response survey data in categorical data analysis: The case of enterprise system implementation in large North American firms. *Journal of Applied Quantitative Methods* **4**:45-53.

Legendre P. 2005. Species Associations: The Kendall coefficient of concordance revisited. *Journal of Agricultural, Biological, and Environmental Statistics* **10**:226-245.

Lenne J M and Ward A F. 2010. Improving the efficiency of domestic vegetable marketing systems in East Africa: Constraints and opportunities. *Outlook on Agriculture* **39**:31–40.

Liang L. 1993. China's post-harvest grain losses and the means of their reduction and elimination. *Journal of Economic Geography* **1**:92-96.

Maiti R, Thakur A K, Gupta A and Mandal D. 2018. Post- harvest management of agricultural produce. *https://www.researchgate.net/publication/330845976* (1:33AM, 14th February 2022). 23p.

Manoj. 2014. Growth, instability and post-harvest losses in Tomato in Jaipur district of Rajasthan. M. Sc. Thesis. Department of Agricultural Economics, Sri Karan Narendra Agriculture University, Jobner. 120p.

Martey E, Al-Hassan R M and Kuwornu J K M. 2012. Commercialization of smallholder agriculture in Ghana: A tobit regression analysis. *African Journal of Agricultural Research* **7**:2131-41.

Mashau M E, Moyane J N and Jideani I A. 2012. Assessment of postharvest losses of fruits at Tshakhuma fruit market in Limpopo province, South Africa. *African Journal of Agricultural Research* **7**:4145-50.

Mebratie M A, Haji J, Woldetsadik K and Ayalew A. 2015. Determinants of postharvest banana loss in the marketing chain of Central Ethiopia. *Food Science and Quality Management* **37**:52-63.

Mbuk E M, Bassey N E, Udoh E and Udoh E J. 2011. Factors influencing postharvest loss of tomatoe in urban market in Uyo, Nigeria. *Nigerian Journal of Agriculture, Food and Environment* **7**: 40-46.

Meena M S, Kumar A, Singh K M and Meena H R. 2009. Farmers' attitude towards post-harvest issues of horticultural crops. *Indian Research Journal of Extension Education* **9**:15-19.

Meena M, Rathore S and Bhimawa B S. 2019. Constraints perceived by farmers in adoption of recommended Aonla (*emblicaofficinalis*) production technologies: Evidences from Udaipur district of Rajasthan, India. *International Journal of Current Microbiology and Applied Sciences* **8**:5-10.

Minten B, Reardon T, Gupta S D, Hu D and Murshid K. 2016. Wastage in food value chains in developing countries: Evidence from the potato sector in Asia. *Food Security in a Food Abundant World* **16**:225-38.

Mishra S P, Sarkar U, Taraphder S, Datta S, Swain D P, Saikhom R, Panda S and Laishram M. 2017. Multivariate statistical data analysis-Principal component analysis (PCA). *International Journal of Livestock Research* **7**:60-78.

Mitrannavar D H and Yeledalli R A. 2014.Estimation of post-harvest losses of major vegetables in Karnataka- A management appraisal. *International Journal of Commerce and Business Management* **7**:349-53.

Muhammad R H, Hionu G C and Olayemi F F. 2012. Assessment of the postharvest knowledge of fruits and vegetable farmers in GarunMallam L.G.A of Kano, Nigeria. *International Journal of Development and Sustainability* **1**:510-515.

Munhuweyi K, Opara U L and Sigge G. 2015. Postharvest losses of cabbages from retail to consumer and the socio-economic and environmental impacts. *British Food Journal* **118**:250-71.

Naik D V, Kavitha M, and Reddy R V S K. 2019. Constraints in adoption of vegetable production technology in Nellore district of Andhra Pradesh, India. *International Journal of Current Microbiology and Applied Sciences* **8**:2931-936.

Nasrin T A, Molla M, Hossaen A, Alam M S and Yasmin L. 2008. Effect of postharvest treatments on shelf life and quality of tomato. *Bangladesh Journal of Agricultural Research* **33**:579-85.

Nuevo P A and Apaga A R. (2010). AARDO workshop on technology reducing postharvest losses and maintaining quality of fruits and vegetables. University of Philippines, Los Banos. 167p.

Nura A. 2015. Postharvest management of fruits and vegetables- A review. *Techno Science Africana Journal* **11**:93-03.

Olorunda A O and Aworh O C. 1983. A quantitative assessment of post-harvest losses of perishable vegetables in the Nigerian marketing system. *Nigerian Journal of Science* **17**:41-49.

Panghal A, Yadav D N, Khatkar B S, Sharma H, Kumar V and Chhikara N. 2018. Post-harvest malpractices in fresh fruits and vegetables: Food safety and health issues in India. *Nutrition and Food Science* **48**:561-78.

Parfitt J, Barthel M and Macnarghton S. 2010. Food waste within food supply chains: Qualification and potential for change to 2050. *Philosophical Transactions of the Royal Society* **365**:3065-81.

Parmar A, Hensel O and Sturma B. 2016. Post-harvest handling practices and associated food losses and limitations in the sweet-potato value chain of Southern Ethiopia. *NJAS - Wageningen Journal of Life Sciences* **30**:1-10.

Pathania A. 2022. Farmers' buying behaviour towards agricultural inputs in high hill temperate wet zone of Himachal Pradesh. PhD. Thesis. Department of Business Management. YSP University of Horticuture and Forestry, Solan. 206p.

Patil R T and Singh D B. 2007. Agricultural engineering for enhanced productivity and employment: Role of post-harvest management and value addition. 41st Annual convention & symposium of Indian Society of Agricultural Engineers, January 29-31, College of Agricultural Engineering and Technology, Agricultural University, Junagarh. **19**:19-30.

Porat R, Lichter A, Terry L A, Harker R and Buzby J. 2018. Postharvest losses of fruit and vegetables during retail and in consumers' homes: Quantifications, cause and means of prevention. *Postharvest Biology and Technology* **139**:135-149.

Raghav S and Sen C. 2014. Constraints faced by the farmers in cultivation of major crops: A case study of Udham Singh Nagar district of Uttarakhand. *GALAXY International Interdisciplinary Research Journal* **2**:11-17.

Raghuvanshi A, Gauraha A K and Chandrakar M R. 2018. Post-harvest losses in potato and factors affecting post-harvest losses at farm level in Chattisgarh. *Journal of Pharmacognosy and Phytochemistry* **7**:3122-24.

Rahman M A, Lalon S B and Surya M H. 2016. Information sources preferred by the farmers in receiving farm information. *International Journal of Agricultural Extension and Rural Development* **3**:258-262.

Rajesh R. 2018. Economic analysis of post- harvest losses of major vegetables. *Trends in Biosciences* **11**:2668-70.

Reddy L S and Kulshrestha P. 2019. Perfroming the KMO and bartlett's test for factor estimating the warehouse efficiency, inventory and customers contentment for E-retail supply chain. *International Journal for Research in Enginerring Application and Management* **5**:1-13.

Reddy S, Ram P R, Sastry T V and Devi I B. 2019. *Agricultural Economics*. 2nd ed. Oxford &IBH Publishing Co.Pvt.Ltd, New Delhi. 697p.

Rohit J, Dubey S K, Singh P, Singh B K and Kumbhare N V. 2017. An Assessment of Constraints Faced by the Farmers in Peri-Urban Vegetable Cultivation. *International Journal of Current Microbiology and Applied Sciences* **6**:2245-51.

Roy S K. 1989. Role of PHT of horticulture crops in India-Trend in food science and technology. *Proceedings of the Second International Food Convention*. pp. 349-356.

Sabuddin A T B. 2017. Postharvest Handling Practices on Vegetable Crops at different Stages of the Distribution Chain: A Case Study in Selangor, Malaysia. M. Sc. Thesis. Department of Social Sciences, Wageningen University and Research, Netherlands. 63p.

Sakhare V D and Patil G S. 2019. Construction Equipment Monitoring: By using relative important indices (RII) analysis. *International Research Journal of Engineering and Technology (IRJET)* **6**:261-263.

Samantaray S K, Prusty S and Raj R K. 2009.Constraints in vegetable production experiences of tribal vegetable growers. *Indian Research Journal of Extension Education* **9**:32-34.

Santos S F, Cardoso R, Borges I, Almeida A, Andrade E, Ferreira I and Ramos L. 2020. Post-harvest losses of fruits and vegetables in supply centers in Salvador, Brazil: Analysis of determinants, volumes and reduction strategies. *Waste Management* **101**:161-70.

Sethi D, Kumar V and Lal H. 2022. Growth and instability in vegetable production in Himachal Pradesh. *Himachal Journal of Agricultural Research* **48**:252-257.

Shah P and Ansari M A. 2020. A study of marketing and production constraints faced by vegetable growers. *Asian Journal of Agricultural Extension, Economics and Sociology* **38**:257-263.

Sharma B. 2018. Post-harvest management of vegetables crops. M.Sc. Department of Agribusiness Management, HICAST, Kathmand. 55p.

Sharma D. 2022. A study on women empowerment in agriculture and its impact on farmers' livelihood in Himachal Pradesh. PhD. Thesis. Department of Business Management.YSP University of Horticuture and Forestry, Solan. 168p.

Sharma G and Singh S P. 2011. Economic analysis of post-harvest losses in marketing of vegetables in Uttarakhand. *Agricultural Economics Research Review* **24**:309-15.

Sharma S. 2016. Economic analysis of post-harvest losses in onion in Jaipur district of Rajasthan. *The Asian Journal of Horticulture* **11**:124-28.

Shee A, Mayanja S , Simba E, Stathers T, Bechoff A and Bennett B. 2019. Determinants of postharvest losses along smallholder producers Maize and Sweetpotato value chains: An ordered probit analysis. *Food Security* **11**:1101-120.

Shreshtha N. 2021. Factor analysis as a tool for survey analysis. *American Journal of Applied Mathematics and Statistics* **9**:4-11.

Singh A K, Singh N and Singh B B. 2013. Marketing and post-harvest loss assessment of vegetables in Varanasi district (U.P.). *International Research Journal of Agricultural Economics and Statistics* **4**:47-50.

Singh A K. 2002. Marketing and Assessment of Post-Harvest Losses of Vegetables in Varanasi District.Ph D. Thesis. Department of Agricultural Economics, Udai Pratap Autonomous College, Varanasi. 92p.

Singh A S and Masuku M B. 2014. Sampling techniques and determination of sample size in applied statistics research: An overview. *International Journal of Economics, Commerce and Management* **2**:1-22.

Singh V and Singh A. 2020. Analysis of agriculture data using principal component analysis. *International Journal of Multidisciplinary Research and Development* **7**:34-37.

Singh V, Hedayetullah M, Zaman P and Meher J. 2014. Postharvest technology of fruits and vegetables: An overview. *Journal of Postharvest Technology* **2**:124-135.

Tadesse F. 1991. Post-harvest losses of fruits and vegetables in horticultural state farms. *Acta Horticulturae* **270**:261-70.

Taherdoost H. 2016. Validity and reliability of the research instrument; How to test the validation of a questionnaire/survey in a research?. *International Journal of Academic Research in Management* **5**:28-36.

Talathi J M, Thorat V A and Kshirsagar P J. 2016. Economics analysis of post-harvest losses in marketing of tomato in Karnataka. *The Asian Journal of Horticulture* **11**:355-60.

Tarek E, Motawa I and Elmasoudi I. 2022. Relative importance index for the key performance indicators for the construction industry in Egypt. *International Journal of Civil and Structural Engineering Research* **10**: 125-131

Thlibon D A, Nujid M M, Mokhtar H, Rahim J A, Aziz N F A and Tarmizi A A A. 2021. Relative importance index (RII) in ranking the factors of employer satisfaction towards industrial training students. *International Journal of Asian Education* **2**:493-503.

Tolulope A and Adeladun A. 2021. Common causes and prevention of post-harvest losses in fruits and vegetables. *Journal of Research in Agriculture and Animal Science* **8**:21-24.

Udas S, Rai B K, Khatiwada P P, Gurang M and Thapa R. 2005. Assessment of postharvest handling systems of vegetables in the Eastern hills of Nepal. In: *Proceeding 5th International Postharvest Symposium*, held at Central campus of technology, Dharan, Nepal. pp. 2191-198.

Underhill S J R and Kumar S. 2015. Quantifying postharvest losses along a commercial tomato supply chain in Fiji: A case study. *Journal of Applied Horticulture* **17**:199-04.

Verbeek M (ed). 2008. *A guide to modern econometrics*. John Wiley and Sons Ltd, Erasmus University Rotterdam. 447p.

Verma A and Singh K P. 2004. An economic analysis of post-harvest losses in fresh vegetables. *Indian Journal of Agricultural Marketing* **18**:136-139.

Verma L. 2000. Postharvest technology of fruits and vegetables: General concepts and principles. *Indus Publishing* **1:** 1-1222.

Viswanathan R, Thangavel K, Kennedy J Z and Kailappan R. 1998. Status of harvest and postharvest losses of tomato in TamilNadu. *Agricultural Engineering Today* **22**:28-35.

Wakholi C, Cho B K, Mo C, Kim M S. 2015. Current state of postharvest fruit and vegetable management in East Africa. *Journal of Biosystems Engineering* **40**:238-49.

Wetherill M S, White K C, Rivera C and Seligman H K. 2018. Challenges and opportunities to increasing fruit and vegetable distribution through the US charitable feeding network: Increasing food systems recovery of edible fresh produce to build healthy food access. *Journal of Hunger and Environmental Nutrition* **14**:1-20.

Yadav S, Prajapati R R and Prajapati M R. 2014. Knowledge and adoption of Tomato growers about improved Tomato production Technology. *Gujarat Journal of Extension Edu*cation **25**:1-3.

Yahaya S M and Mardiyya A Y. 2019. Review of post-harvest losses of fruits and vegetables. *Journal of Scientific and Technical Research* **13**:10192-200.

Yahia E M. 2006. Controlled atmospheres for tropical fruits. In: Yahia E M (ed). The current status and future application of modified and controlled atmospheres for Horticultural commodities. *Stewart Postharvest review* **5**:1-10.

Yeshiwas Y and Tadele E. 2021. An investigation into major causes for postharvest losses of horticultural crops and their handling practice in Debre Markos, North-Western Ethiopia. *Advances in Agriculture* :1-10.

Zalkuwi J, Singh R, Bhattarai M, Singh O P and Rao D. 2015. Analysis of constraints influencing sorghum farmers using Garrett's ranking technique: A comparative study of India and Nigeria. *International Journal of Scientific Research and Management* **3**: 2435-440.

APPENDICES

Appendix-I: Survey schedule for data collection

Survey Schedule

Dear Sir/Madam

I am working on thesis entitled **"Management of Post-Harvest Losses by Farmers' during Marketing of Vegetable Crops in the State of Himachal Pradesh"** as a part of my Ph.D. research. Kindly read the following statements carefully and give your response. I assure you that whatever information is provided by you will be used for the research and academic purpose and will be kept confidential. I shall be highly grateful to you for your co-operation.

Name of the respondent	
District	
Block	
Panchayat	
Village	

Section- A

Demographic Profile of respondents

Q.1 Gender of the respondent

- Male ☐
- Female ☐
- Others ☐

Q.2 Age Status of the respondent (in years)

- <18 ☐
- 19-35 ☐
- 35-50 ☐
- Above 50 ☐

Q.3 Education Qualification

- Up to 10th ☐
- Up to graduation ☐
- Post-graduation and above ☐
- Professional qualified ☐

Q.6 Family Type

- Nuclear ☐
- Extended ☐

Q.7 Land holding capacity of the respondent

- Marginal (0-1 hac) ☐
- Small (1-2 hac) ☐
- Semi medium (2-4hac) ☐
- Medium (4-10hac) ☐
- Large (above 10hac) ☐

Q.8 Experience status in farming

- <5 years ☐
- 5-10 years ☐
- 10-15 years ☐
- Above 15 years ☐

Q.4 Occupation status

Farming only Profession	
Farming (with Subsidiary profession)	
Private job	
Government job	
Retired	

Q.9 When you have surplus, whom do you supply?

Local Market	
Commission Agent	
APMC	
Preharvest contractor	
Postharvest contractor	

Q.5 Income status (Rs/annum)

Less than 5 lakhs	
5-10 lakhs	
10-15 lakhs	
Above 15 lakhs	

Existing status of post-harvest losses during marketing of selected vegetable crops

Q.10 Post-harvest Losses (in quintals) of selected vegetable crops from 2020-2023

Year / Crop Loss	2020- 2021	2021-2022	2022-2023
Tomato			
Cabbage			
Green Pea			

Q.11 Quantity of produce lost per harvesting season in selected vegetable crop

Crops	Total Production (quintal)	Stages of Post-harvest Losses (%)			
		Post-harvest handling	Grading & Packaging	Transportation	Storage & Marketing
Tomato					
Cabbage					
Pea					

SECTION- B

Factors affecting post-harvest losses of farmers' during marketing of selected vegetable crops and the management practices adopted by the farmer:-

Q.12 Total quantity of produce lost during post-harvest as per harvesting season in selected vegetable crops

Total PHL in Vegetable Crop (%)		
Low	Moderate	High
< 5	5-25	>25

Q.13 Factors affecting post-harvest losses in different operations during marketing of selected vegetable crops

A) TOMATO

Factors	Yes	No
Post-harvest handling training		
Time of harvest		
Method of harvesting		
Labor used for harvesting		
Type of packaging		
Distance to the market		
Time and place of sale		
Storage facility		
Access to the market information		

B) CABBAGE

Factors	Yes	No
Post-harvest handling training		
Time of harvest		
Method of harvesting		
Labor used for harvesting		
Type of packaging		
Distance to the market		
Time and place of sale		
Storage facility		
Access to the market information		

C) GREEN PEA

Factors	Yes	No
Post-harvest handling training		
Time of harvest		
Method of harvesting		
Labor used for harvesting		
Type of packaging		
Distance to the market		
Time and place of sale		
Storage facility		
Access to the market information		

Q.14 Conditions of post-harvest leading maximum damage to selected vegetable crops, rank them in the order of loss

A) TOMATO

Post-harvest Losses in different conditions/ Rank	I	II	III	IV	V
Transportation					
Storage					
Handling Damages					
Under/Over maturity					
Marketing					
Environmental conditions					
Pest and Disease					
Rotting					
Cleaning and Grading					
Packaging					
Others (Contagious)					

B) CABBAGE

Post-harvest Losses in different conditions/ Rank	I	II	III	IV	V
Pest and disease					
Rotting					
Cleaning and grading					
Transportation					
Under/over maturity					
Marketing					
Environmental condition					
Handling damages					
Packaging					
Storage					
Others (Contagious)					

C) GREEN PEA

Post-harvest Losses in different conditions/ Rank	I	II	III	IV	V
Pest and disease					
Rotting					
Cleaning and grading					
Transportation					
Under/over maturity					
Marketing					
Environmental condition					
Handling damages					
Packaging					
Storage					
Others (Contagious)					

***Note : I-** Extremely high, **II-** High, **III-** Moderate, **IV-** Low, **V-** Extremely low*

Q.15 Farm management practices adopted by farmers during marketing of vegetables in each stage to reduce post-harvest losses

A) TOMATO

Factor	**Management Practices**	**SA**	**A**	**N**	**D**	**SD**
Harvesting						
	Harvest at proper mature					
	Mechanical harvesting					
	Harvesting done by the trained workers					
	Harvesting done in morning/evening hours					
Sorting/Grading						
	Remove vegetables which are:					
	Damaged					
	Infected with diseases					
	Over matured					
	Rotten vegetables					
Post- harvest Treatment						
	Washing					
	Waxing					
	Pre-cooling					
	Pest or Fungus treatment					
Packaging						
	Not overfilled					
	Provide good aeration					
	Good packaging material according to the crop					
Transportation						
	Careful handling during loading and unloading					
	Clean and ventilated vehicle					
	Transport during cool hours					
	Transportation in refrigerated trucks					

***Note: SA-** Strongly Agree, **A-** Agree, **N-** Neutral, **D-** Disagree, **SD-** Strongly disagree*

B) CABBAGE

Factor	Management Practices	SA	A	N	D	SD
Harvesting						
	Harvest at proper mature					
	Mechanical harvesting					
	Harvesting done by the trained workers					
	Harvesting done in morning/evening hours					
Sorting/Grading						
	Remove vegetables which are:					
	Damaged					
	Infected with diseases					
	Over matured					
	Rotten vegetables					
Post- harvest Treatment						
	Washing					
	Waxing					
	Pre-cooling					
	Pest or Fungus treatment					
Packaging						
	Not overfilled					
	Provide good aeration					
	Good packaging material according to the crop					
Transportation						
	Careful handling during loading and unloading					
	Clean and ventilated vehicle					
	Transport during cool hours					
	Transportation in refrigerated trucks					

***Note: SA-** Strongly Agree, **A-** Agree, **N-** Neutral, **D-** Disagree, **SD-** Strongly disagree*

C) GREEN PEA

Factor	Management Practices	SA	A	N	D	SD
Harvesting						
	Harvest at proper mature					
	Mechanical harvesting					
	Harvesting done by the trained workers					
	Harvesting done in morning/evening hours					
Sorting/Grading						
	Remove vegetables which are:					
	Damaged					
	Infected with diseases					
	Over matured					
	Rotten vegetables					
Post- harvest Treatment						
	Washing					
	Waxing					
	Pre-cooling					
	Pest or Fungus treatment					
Packaging						
	Not overfilled					
	Provide good aeration					
	Good packaging material according to the crop					
Transportation						
	Careful handling during loading and unloading					
	Clean and ventilated vehicle					
	Transport during cool hours					
	Transportation in refrigerated trucks					

Note: SA- *Strongly Agree,* ***A-*** *Agree,* ***N-*** *Neutral,* ***D-*** *Disagree,* ***SD-*** *Strongly disagree*

Q.16 Source of information performed by farmer to adopt farm management practices for post-harvest losses

Source of information	Low	Moderate	High	Yes	No
Informal sources					
Family members					
Fellow farmers/Peer groups					
Neighbors					
Friends/Relative					
Formal sources					
Extension functionaries of state government					
Krishi Vigyan Kendra (KVK)					
Scientists' interaction					
Agricultural/Horticultural Universities					
Training/seminars/workshop provided by government institutions					
Mass Media					
Newspaper and print media					
Radio and TV					
Mobile/social media					

SECTION-C

Constraints and Suggest management intervention for managing post- harvest losses

Q.17 Problems faced by the farmer during marketing of selected vegetable crops

A) TOMATO

Constraints	I	II	III	IV	V
Production Constraints					
Non availability of planting material on time					
Non availability of high yielding variety seed					
Non availability of market information					
Lack of irrigation facilities					
Non availability of labor on time					
Marketing Constraints					
Lack of transportation					
Fluctuation in marketing prices					
Absence of regulated market					
Distant market					
Lacking in grading and packaging					
Long chain of intermediaries					
Financial Constraints					
High cost of planting material					
High cost of pesticides and fertilizers					
High cost of labor					
Non-availability of credit in time					
Low prices of the produce					
High initial investment on infrastructure					
High payback period in investment					
Unawareness of insurance facilities in case of risk					
Technical and Infrastructural Constraints					
Lack of proper storage and infrastructural facilities					
Non availability of vegetable growing and marketing related information through SMS/Internet					
Lack of training on postharvest handling practices and technologies					
Lack of processing facility					
Education Constraint					
Lack of basic knowledge about PHM practices					
Lack of mass media exposure on this topic					
Lack of prior experience					
Lack of willingness to take initiative					
Lack of motivation and skill about proper production					

Note : I- *Extremely high,* ***II-*** *High,* ***III-*** *Moderate,* ***IV-*** *Low,* ***V-*** *Extremely low*

B) CABBAGE

Constraints	**I**	**II**	**III**	**IV**	**V**
Production Constraints					
Non availability of planting material on time					
Non availability of high yielding variety seed					
Non availability of market information					
Lack of irrigation facilities					
Non availability of labor on time					
Marketing Constraints					
Lack of transportation					
Fluctuation in marketing prices					
Absence of regulated market					
Distant market					
Lacking in grading and packaging					
Long chain of intermediaries					
Financial Constraints					
High cost of planting material					
High cost of pesticides and fertilizers					
High cost of labor					
Non-availability of credit in time					
Low prices of the produce					
High initial investment on infrastructure					
High payback period in investment					
Unawareness of insurance facilities in case of risk					
Technical and Infrastructural Constraints					
Lack of proper storage and infrastructural facilities					
Non availability of vegetable growing and marketing related information through SMS/Internet					
Lack of training on postharvest handling practices and technologies					
Lack of processing facility					
Education Constraint					
Lack of basic knowledge about PHM practices					
Lack of mass media exposure on this topic					
Lack of prior experience					
Lack of willingness to take initiative					
Lack of motivation and skill about proper production					

Note : I- *Extremely high,* ***II-*** *High,* ***III-*** *Moderate,* ***IV-*** *Low,* ***V-*** *Extremely low*

C) GREEN PEA

Constraints	I	II	III	IV	V
Production Constraints					
Non availability of planting material on time					
Non availability of high yielding variety seed					
Non availability of market information					
Lack of irrigation facilities					
Non availability of labor on time					
Marketing Constraints					
Lack of transportation					
Fluctuation in marketing prices					
Absence of regulated market					
Distant market					
Lacking in grading and packaging					
Long chain of intermediaries					
Financial Constraints					
High cost of planting material					
High cost of pesticides and fertilizers					
High cost of labor					
Non-availability of credit in time					
Low prices of the produce					
High initial investment on infrastructure					
High payback period in investment					
Unawareness of insurance facilities in case of risk					
Technical and Infrastructural Constraints					
Lack of proper storage and infrastructural facilities					
Non availability of vegetable growing and marketing related information through SMS/Internet					
Lack of training on postharvest handling practices and technologies					
Lack of processing facility					
Education Constraint					
Lack of basic knowledge about PHM practices					
Lack of mass media exposure on this topic					
Lack of prior experience					
Lack of willingness to take initiative					
Lack of motivation and skill about proper production					

Note : I- *Extremely high,* ***II-*** *High,* ***III-*** *Moderate,* ***IV-*** *Low,* ***V-*** *Extremely low*

Q.18 Read the following statement carefully and ticks the suitable option for reducing the Post-Harvest Losses

A) TOMATO

Suggestive Measures	**SA**	**A**	**N**	**D**	**SD**
Careful handling during harvesting, transportation and storage					
Harvesting at maturity stage					
Provide storage facilities					
Proper packaging with proper labeling					
Management of pre-harvest production practices					
Provide effective market information					
Training on new technologies and market strategies					

***Note: SA-** Strongly Agree, **A-** Agree, **N-** Neutral, **D-** Disagree, **SD-** Strongly disagree*

B) CABBAGE

Suggestive Measures	**SA**	**A**	**N**	**D**	**SD**
Careful handling during harvesting, transportation and storage					
Harvesting at maturity stage					
Provide storage facilities					
Proper packaging with proper labeling					
Management of pre-harvest production practices					
Provide effective market information					
Training on new technologies and market strategies					

***Note: SA-** Strongly Agree, **A-** Agree, **N-** Neutral, **D-** Disagree, **SD-** Strongly disagree*

C) GREEN PEA

Suggestive Measures	**SA**	**A**	**N**	**D**	**SD**
Careful handling during harvesting, transportation and storage					
Harvesting at maturity stage					
Provide storage facilities					
Proper packaging with proper labeling					
Management of pre-harvest production practices					
Provide effective market information					
Training on new technologies and market strategies					

***Note: SA-** Strongly Agree, **A-** Agree, **N-** Neutral, **D-** Disagree, **SD-** Strongly disagree*

APPENDIX-II

ANNEXURE-I

Percentage position and their corresponding Garrett Table values for marketing of selected vegetable crop related field to market level loss

Rank	Percent Position	Garratt Score
1	10	75
2	30	60
3	50	50
4	70	40
5	90	24

ANNEXURE-I I

Ranking to field-to-market-level loss conditions which lead maximum damage to Tomato crop producein the study area

PHL in Diff Condition	I	II	III	IV	V	Total Score
Transportation	2025	4920	4100	4640	1272	16957
Storage	525	2040	4850	4000	2928	14343
Handling Damages	1275	6720	7000	1800	1104	17899
Under/Over maturity	3975	5820	6450	2520	432	19197
Inadequate market facility	6825	6240	5900	1480	240	20685
Environmental conditions	14325	5340	2600	830	144	23289
Pest and disease	16050	4980	2350	440	120	23940
Rotting	5250	7440	5300	1840	336	20166
Cleaning and Grading	1425	2100	5250	5800	1344	15919
Packaging	1575	900	4050	5640	2448	14613

ANNEXURE-III

Ranking to field-to-market-level loss conditions which lead maximum damage to Cabbage crop produce in the study area

PHL in Diff Condition	I	II	III	IV	V	TotalScore
Pest and disease	8550	9720	3200	800	0	22270
Rotting	1800	5880	6000	2880	1104	17664
Cleaning and grading	5250	8880	5200	560	576	20466
Transportation	6675	7980	5450	800	216	21121
Under/over maturity	8100	9720	3850	440	48	22158
Inadequate market facility	15150	6240	2300	200	72	23962
Environmental condition	17400	4260	1850	600	120	24230
Handling damages	7200	5940	5750	1720	168	20778
Packaging	2025	1500	5000	6280	1224	16029
Storage	1875	900	4150	6360	1872	15157

ANNEXURE-IV

Ranking to field-to-market-level loss conditions which lead maximum damage to Green pea crop produce in the study area

PHL in Diff Condition	I	II	III	IV	V	Total Score
Pest and disease	11550	8880	1950	520	144	23044
Rotting	2625	6900	5550	2240	1032	18347
Cleaning and grading	4875	8220	4650	1800	480	20025
Transportation	8400	8340	4650	440	120	21950
Under/over maturity	8400	9420	3750	360	168	22098
Inadequate market facility	15075	6000	2450	400	0	23925
Environmental condition	16800	4680	2400	360	24	24264
Handling damages	7425	4980	5650	2360	144	20559
Packaging	1800	1860	5350	5320	1560	15890
Storage	1125	1980	4100	5480	2232	14917

ANNEXURE-V

Ranking to field-to-market-level loss conditions which lead maximum damage to Tomato crop produce in Solan district

PHL in Diff Condition	I	II	III	IV	V	Total Score
Pest and disease	300	180	1000	2440	768	4688
Rotting	300	360	450	1480	1536	4126
Cleaning and grading	150	780	2100	1320	720	5070
Transportation	600	600	2650	1520	264	5634
Under/over maturity	1350	720	2800	1120	144	6134
Inadequate market facility	5100	1260	900	320	120	7700
Environmental condition	5550	1800	600	40	72	8062
Handling damages	2250	2880	1100	320	288	6838
Packaging	525	720	950	1640	984	4819
Storage	750	360	950	1000	1440	4500

ANNEXURE-VI

Ranking to field-to-market-level loss conditions which lead maximum damage to Cabbage crop produce in Solan district

PHL in Diff Condition	I	II	III	IV	V	Total Score
Pest and disease	4650	1800	950	360	0	7760
Rotting	1275	1560	1650	960	480	5925
Cleaning and grading	2325	2340	1700	200	264	6829
Transportation	3225	2340	1350	280	96	7291
Under/over maturity	3675	2700	1150	120	0	7645
Inadequate market facility	7050	900	400	80	24	8454
Environmental condition	7350	720	200	120	72	8462
Handling damages	4200	1980	700	400	168	7448
Packaging	1200	420	1200	1880	624	5324
Storage	975	480	700	1920	888	4963

ANNEXURE-VII

Ranking to field-to-market-level loss conditions which lead maximum damage to Green pea crop produce in Solan district

PHL in Diff Condition	I	II	III	IV	V	Total Score
Pest and disease	5850	1320	350	360	96	7976
Rotting	1650	1380	1450	1320	312	6112
Cleaning and grading	1875	2040	900	1200	312	6327
Transportation	4125	2460	750	240	72	7647
Under/over maturity	3600	2760	1000	200	24	7584
Inadequate market facility	7200	1200	150	40	0	8590
Environmental condition	7275	660	350	160	24	8469
Handling damages	3825	1560	950	720	144	7199
Packaging	750	600	1200	1400	984	4934
Storage	825	900	450	1600	1080	4855

ANNEXURE-VIII

Ranking to field-to-market-level loss conditions which lead maximum damage to Tomato crop produce in Mandi district

PHL in Diff Condition	I	II	III	IV	V	Total Score
Pest and disease	675	3000	1300	1120	168	6263
Rotting	225	960	2700	1160	432	5477
Cleaning and grading	900	3420	2250	240	0	6810
Transportation	1950	2640	1850	520	0	6960
Under/over maturity	2925	2700	1650	120	0	7395
Inadequate market facility	4350	1920	1000	400	0	7670
Environmental condition	5100	1380	1100	200	48	7828
Handling damages	1200	1680	2450	1080	0	6410
Packaging	525	420	3050	1720	48	5763
Storage	375	180	2000	2240	384	5179

ANNEXURE-IX

Ranking to field-to-market-level loss conditions which lead maximum damage to Cabbage crop produce in Mandi district

PHL in Diff Condition	I	II	III	IV	V	Total Score
Pest and disease	1200	4320	1300	240	0	7060
Rotting	225	2460	2850	680	48	6215
Cleaning and grading	1575	3600	1850	80	0	7105
Transportation	1875	2400	2300	360	0	6935
Under/over maturity	2325	3180	1500	240	0	7245
Inadequate market facility	3375	2820	1250	40	48	7485
Environmental condition	3900	2100	1000	440	48	7440
Handling damages	1275	1320	2700	1080	0	6375
Packaging	525	480	2550	2040	72	5595
Storage	300	180	1050	1960	312	3490

ANNEXURE-X

Ranking to field-to-market-level loss conditions which lead maximum damage to Green pea crop produce in Mandi district

PHL in Diff Condition	I	II	III	IV	V	Total Score
Pest and disease	1875	4200	950	160	48	7233
Rotting	375	3120	2600	280	96	6471
Cleaning and grading	1650	2760	2550	40	0	7000
Transportation	1575	3060	2400	0	0	7035
Under/over maturity	2025	3120	1800	120	48	7113
Inadequate market facility	3075	2580	1550	200	0	7405
Environmental condition	3750	2160	1450	200	0	7560
Handling damages	825	1440	2700	1240	0	6205
Packaging	600	660	2750	1760	48	5818
Storage	150	480	2600	2040	168	5438

ANNEXURE-XI

Ranking to field-to-market-level loss conditions which lead maximum damage to Tomato crop produce in Shimla district

PHL in Diff Condition	I	II	III	IV	V	Total Score
Pest and disease	1050	1740	1800	1080	336	6006
Rotting	0	720	1700	1360	960	4740
Cleaning and grading	225	2520	2650	240	384	6019
Transportation	1425	2580	1950	480	168	6603
Under/over maturity	2550	2820	1450	240	96	7156
Inadequate market facility	4875	2160	700	160	24	7919
Environmental condition	5400	1800	650	200	0	8050
Handling damages	1800	2880	1750	440	48	6918
Packaging	375	960	1250	2440	312	5337
Storage	450	360	1100	2400	624	4934

ANNEXURE-XII

Ranking to field-to-market-level loss conditions which lead maximum damage to Cabbage crop produce in Shimla district

PHL in Diff Condition	I	II	III	IV	V	Total Score
Pest and disease	2700	3600	950	200	0	7450
Rotting	300	1860	1500	1240	576	5476
Cleaning and grading	1350	2940	1650	280	312	6532
Transportation	1575	3240	1800	160	120	6895
Under/over maturity	2100	3840	1200	80	48	7268
Inadequate market facility	4725	2520	650	80	0	7975
Environmental condition	6150	1440	650	40	0	8280
Handling damages	1725	2640	2350	240	0	6955
Packaging	300	600	1250	2360	528	5038
Storage	600	240	900	2480	672	4892

ANNEXURE-XIII

Ranking to field-to-market-level loss conditions which lead maximum damage to Green pea crop produce in Shimla district

PHL in Diff Condition	I	II	III	IV	V	Total Score
Pest and disease	3825	3360	650	0	0	7835
Rotting	600	2400	1500	640	624	5764
Cleaning and grading	1350	3420	1200	560	168	6698
Transportation	2700	2820	1500	200	48	7268
Under/over maturity	2775	3540	950	40	96	7401
Inadequate market facility	4800	2220	750	160	0	7930
Environmental condition	5775	1860	600	0	0	8235
Handling damages	2775	1980	2000	400	0	7155
Packaging	450	600	1400	2160	528	5138
Storage	150	600	1050	1840	984	4624

ANNEXURE-XIV

Ranking to suggestion for managing post-harvest losses during marketing of Tomato crops in the study area

Suggestive Measure	SA	A	N	D	SD	Total
Careful handling during harvesting, transportation and storage	1000	556	60	0	1	1617
Harvesting at maturity stage	550	860	150	0	0	1560
Provide storage facilities	660	712	150	0	0	1522
Proper packaging with proper labeling	170	668	102	0	0	940
Management of pre-harvest production practices	975	520	105	0	0	1600
Provide effective market information	1095	424	105	0	0	1624
Training on new technologies and market strategies	1130	360	132	0	0	1622

ANNEXURE-XV

Ranking to suggestion for managing post-harvest losses during marketing of cabbage crops in the study area

Suggestive Measure	SA	A	N	D	SD	Total
Careful handling during harvesting, transportation and storage	525	896	93	0	0	1514
Harvesting at maturity stage	515	804	165	2	0	1486
Provide storage facilities	610	684	195	4	0	1493
Proper packaging with proper labeling	840	532	171	4	0	1547
Management of pre-harvest production practices	855	568	138	2	0	1563
Provide effective market information	980	504	114	0	0	1598
Training on new technologies and market strategies	1095	372	138	2	1	1608

ANNEXURE-XV

Ranking to suggestion for managing post-harvest losses during marketing of Green peacrops in the study area

Suggestive Measure	SA	A	N	D	SD	Total
Careful handling during harvesting, transportation and storage	580	724	177	6	1	1488
Harvesting at maturity stage	600	560	297	0	1	1458
Provide storage facilities	540	528	351	2	2	1423
Proper packaging with proper labeling	655	620	213	2	2	1492
Management of pre-harvest production practices	780	580	171	0	2	1533
Provide effective market information	875	584	111	2	1	1573
Training on new technologies and market strategies	950	444	168	6	0	1568

ANNEXURE-XVI

Ranking to suggestion for managing post-harvest losses during marketing of Tomato crops in the Solan district

Suggestive Measure	SA	A	N	D	SD	Total
Careful handling during harvesting, transportation and storage	270	212	36	0	1	519
Harvesting at maturity stage	245	192	69	0	0	506
Provide storage facilities	160	240	84	0	0	484
Proper packaging with proper labeling	230	236	45	0	0	511
Management of pre-harvest production practices	310	172	45	0	0	527
Provide effective market information	375	108	54	0	0	537
Training on new technologies and market strategies	360	92	75	0	0	527

ANNEXURE-XVII

Ranking to suggestion for managing post-harvest losses during marketing of Cabbage crops in the Solan district

Suggestive Measure	SA	A	N	D	SD	Total
Careful handling during harvesting, transportation and storage	215	232	57	0	0	504
Harvesting at maturity stage	175	232	78	2	0	487
Provide storage facilities	185	236	66	4	0	491
Proper packaging with proper labeling	185	240	63	4	0	492
Management of pre-harvest production practices	285	172	57	2	0	516
Provide effective market information	260	200	54	0	0	514
Training on new technologies and market strategies	275	148	78	2	1	504

ANNEXURE-XVIII

Ranking to suggestion for managing post-harvest losses during marketing of Green pea crops in the Solan district

Suggestive Measure	SA	A	N	D	SD	Total
Careful handling during harvesting, transportation and storage	205	224	57	6	1	493
Harvesting at maturity stage	195	164	117	0	1	477
Provide storage facilities	150	172	132	2	2	458
Proper packaging with proper labeling	175	200	96	2	2	475
Management of pre-harvest production practices	225	212	60	0	2	499
Provide effective market information	230	228	45	2	1	506
Training on new technologies and market strategies	200	200	81	6	0	487

ANNEXURE-XIX

Ranking to suggestion for managing post-harvest losses during marketing of Tomato crops in the Mandi district

Suggestive Measure	SA	A	N	D	SD	Total
Careful handling during harvesting, transportation and storage	330	204	9	0	0	543
Harvesting at maturity stage	205	312	3	0	0	520
Provide storage facilities	285	232	15	0	0	532
Proper packaging with proper labeling	325	184	27	0	0	536
Management of pre-harvest production practices	320	180	33	0	0	533
Provide effective market information	385	144	21	0	0	550
Training on new technologies and market strategies	415	132	12	0	0	559

ANNEXURE-XX

Ranking to suggestion for managing post-harvest losses during marketing of Cabbage crops in the Mandi district

Suggestive Measure	SA	A	N	D	SD	Total
Careful handling during harvesting, transportation and storage	105	372	18	0	0	495
Harvesting at maturity stage	140	296	54	0	0	490
Provide storage facilities	215	200	81	0	0	496
Proper packaging with proper labeling	300	160	60	0	0	520
Management of pre-harvest production practices	245	220	48	0	0	513
Provide effective market information	375	140	30	0	0	545
Training on new technologies and market strategies	415	112	27	0	0	554

ANNEXURE-XXI

Ranking to suggestion for managing post-harvest losses during marketing of Green pea crops in the Mandi district

Suggestive Measure	SA	A	N	D	SD	Total
Careful handling during harvesting, transportation and storage	185	280	39	0	0	504
Harvesting at maturity stage	220	212	69	0	0	501
Provide storage facilities	235	192	75	0	0	502
Proper packaging with proper labeling	270	216	36	0	0	522
Management of pre-harvest production practices	260	212	45	0	0	517
Provide effective market information	285	216	27	0	0	528
Training on new technologies and market strategies	305	180	42	0	0	527

ANNEXURE-XXII

Ranking to suggestion for managing post-harvest losses during marketing of Tomato crops in the Shimla district

Suggestive Measure	SA	A	N	D	SD	Total
Careful handling during harvesting, transportation and storage	400	140	15	0	0	555
Harvesting at maturity stage	100	356	33	0	0	489
Provide storage facilities	215	240	51	0	0	506
Proper packaging with proper labeling	240	248	30	0	0	518
Management of pre-harvest production practices	345	168	27	0	0	540
Provide effective market information	335	172	30	0	0	537
Training on new technologies and market strategies	355	136	45	0	0	536

ANNEXURE-XXIII

Ranking to suggestion for managing post-harvest losses during marketing of Cabbage crops in the Shimla district

Suggestive Measure	SA	A	N	D	SD	Total
Careful handling during harvesting, transportation and storage	205	292	18	0	0	515
Harvesting at maturity stage	200	276	33	0	0	509
Provide storage facilities	210	248	48	0	0	506
Proper packaging with proper labeling	355	132	48	0	0	535
Management of pre-harvest production practices	325	176	33	0	0	534
Provide effective market information	345	164	30	0	0	539
Training on new technologies and market strategies	405	112	33	0	0	550

ANNEXURE-XXIV

Ranking to suggestion for managing post-harvest losses during marketing of Green pea crops in the Shimla district

Suggestive Measure	SA	A	N	D	SD	Total
Careful handling during harvesting, transportation and storage	190	220	81	0	0	491
Harvesting at maturity stage	185	184	111	0	0	480
Provide storage facilities	155	164	144	0	0	463
Proper packaging with proper labeling	210	204	81	0	0	495
Management of pre-harvest production practices	295	156	66	0	0	517
Provide effective market information	360	140	39	0	0	539
Training on new technologies and market strategies	445	64	45	0	0	554

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Title of the Thesis	**:**	**Management of Post-Harvest Losses by Farmers' during Marketing of Vegetable Crops in the State of Himachal Pradesh**
Name of the Student	**:**	**Priyanka Sharma**
Admission Number	**:**	ABM-2020-03-D
Major Discipline	**:**	Agribusiness Management
Minor Discipline	**:**	Agricultural Economics
Date of Thesis Submission	**:**	
Total Pages of the thesis	**:**	155+xxiii
Major Advisor	**:**	**Dr. Piyush Mehta**

ABSTRACT

The present study focused on the management of post-harvest losses (PHL) by farmers during the marketing of vegetable crops in Himachal Pradesh, specifically targeting Tomato, Cabbage, and Green pea. Solan, Shimla, and Mandi emerged as key districts with significant vegetable concentrations, forming the primary basis for sample selection. Employing a multi-stage random sampling technique, data was collected from 360 farmers, with additional secondary data sourced from publications and government departments. The findings revealed varying trends in post-harvest losses across the selected crops and districts. While cabbage losses decreased, tomato losses increased significantly, and green pea losses exhibited fluctuations, with Shimla experiencing the highest losses. The ordered probit regression model identified factors influencing losses, including handling training, harvest time, distance to market, packaging, harvest method, storage facility, and market information access. Challenges in agricultural ecosystems, such as high-yielding seeds, lengthy marketing chains, high costs, lack of storage facilities, and insufficient post-harvest management knowledge, were highlighted using Kendall's coefficient of concordance. The relative importance index underscored farmers' strategies for reducing losses, emphasizing market insights and efficient packaging. In conclusion, the study recommended the formulation of a comprehensive policy strategy to address post-harvest losses. This strategy should encompass infrastructure development, improved market accessibility, adoption of modern technology, quality control measures, research initiatives, financial assistance, and collaboration with agricultural extension services. These interventions aim to enhance the resilience of farmers against PHL, ensuring sustainable agricultural practices and food security in the state.

Signature of the Student	**Signature of the Major Advisor**
Name: Priyanka Sharma	**Name: Dr. Piyush Mehta**
Date:	**Date:**

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(Priyanka Sharma)