

Takushoku University



POSTHARVEST LOSSES OF VEGETABLES IN NEPAL AND EFFECTIVE MITIGATION MEASURES

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By

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Abstracts

The postharvest loss rate in developing countries is about 20 to 50 percent of the total production. Resolving postharvest losses can help the economy and living standards of the farmers as well as aid in food sustainability. This study is based on all those factors that help find the proper solution to Nepal's postharvest loss of vegetables.

Postharvest losses of vegetables are a significant challenge for all farmers, wholesalers, and retailers involved in vegetable cultivation. Keeping this in mind, this study on postharvest losses focuses on the causes of postharvest losses in Nepal and what kind of initiatives are needed to solve those problems. In this study, considering the previous research done in the concerned sectors, an attempt has been made to solve the issues not explored by the earlier researchers.

The main objective of this study is how to reduce postharvest losses in Nepal. It is based on what is needed to solve the problem and why, despite Nepal being an agricultural country, the rate of postharvest losses in Nepal is higher than in other developing countries. To perceive the causes of postharvest losses in Nepal and explore where and why the high loss rate is. Also, why and

how the loss rate is low in developing countries and what should be done to reduce the loss rate in Nepal as in developing countries is another objective of the study.

The study was conducted in different locations in Nepal and Japan; in the context of Nepal, the survey was based on farmers, wholesalers, and retailers in the Himalayan, Hilly, and Terai districts, so the study covers all scenarios of Nepal. Also, this type of study is entirely new in the context of Nepal, and it can be called the study's originality. This study has also succeeded in identifying the leading causes of postharvest losses in Nepal and finding solutions for postharvest losses of vegetables in different segments. The survey findings are also different from the findings of other researchers, so it can also be called the originality of this study.

Postharvest losses of vegetables occur at all points in the market chain area, from production to food on plates for consumption. Postharvest activities include harvesting, handling, storage, processing, packaging, transportation, and marketing. The loss of horticultural produce is a significant problem in the postharvest chain. It can be caused by various factors, ranging from growing conditions to handling at the retail level. The losses are not only a waste of food but also a waste of human effort, agricultural inputs, livelihoods, investments, and scarce resources such as water. This study aims to find out the actual causes of postharvest losses and provide appropriate solutions for them.

This thesis consists of six chapters, each having its respective contents.

In 1st chapter, "Introduction," all the study background and material from other branches have been described.

Chapter 2nd contains the "postharvest practice and losses of the vegetables." This chapter considered the causes of postharvest losses of vegetables from production to consumer level and the harvesting technology of Nepalese farmers. Apart from this, government policies and agricultural implementations are also included. The study was conducted in Nepal (Kathmandu, Bhaktapur, Lalitpur, Syangja, Plapa, Gorkha, Rupandehi and Kapilbastu district).

The 3rd chapter is "Postharvest practice and food losses in Japan." The study covers the current state of food loss in Japan and its potential for mitigation and postharvest practices, and their role in food losses are carried out in this chapter. This chapter covers the stages of agricultural

development in Japan, the stages of development of agricultural technology, government subsidies in the farming sector, modern agricultural technology, vegetable distribution medium and modern agricultural materials used in it, etc.

The study was conducted with secondary and primary data collection methods. Preliminary data were collected from farmers, suppliers (wholesalers), and retailers by questionnaire. Secondary data were collected from published and unpublished books and other Internet sources. Three central regions of Japan, Saitama, Kanagawa, and Tokyo, have been selected for the survey.

The 4th chapter is about the "postharvest losses of tomatoes in Nepal." The reason for choosing Tomato among the different vegetables for the study, many farmers in Nepal cultivate only tomatoes throughout the year. And Tomato is known as a highly perishable vegetable, so that it can be represented all kinds of vegetables on postharvest losses. The study was carried out in the different municipalities of the Kavrepalanchowk district. Kavrepalanchok district is 21 kilometers east of the country's capital.

The 5th chapter is "Climate change and its effects on postharvest losses." The study is conducted with only a secondary data collection method. This chapter focuses on how climate change affects agriculture and what can be done to sustain vegetable farming in the face of climate change.

Agricultural production is highly climate-dependent since crop growth is influenced by solar radiation, temperature, and rainfall also sensitive to climate variability and weather extremes (droughts, floods, and severe storms). Climate change will affect the productivity of crops and harm their quality, so climate change cannot ignore during the analysis of the postharvest losses.

The 6th chapter is "Conclusion and summary," This chapter focuses on the research's concrete results and the entire study's findings.

This study found that there are postharvest losses in all supply chain channels at the farmers, wholesalers, and retailers, but the higher rate is at the level of farmers. This result differs from the findings of other researchers related to postharvest losses in Nepal so far. And the reason behind this is a lack of education about harvesting time, harvesting equipment, disease and insects, improper packaging, sorting, handling, storage facilities, lack of market access, etc. The

study has also revealed that the farmers' activities also significantly impact the postharvest losses on other parties, wholesalers, and retailers. For example, farmers do not pay much attention to vegetable selection, packaging, and other postharvest processes, which increases the possibility of more losses on the wholesaler's and retailer's sides.

Although most Nepali is engaged in agriculture, the import of agricultural products in Nepal is increasing yearly. As a result, Nepalese farmers cannot meet the Nepalese market's demands. The general economic situation in Nepal can be significantly improved by improving Nepal's agricultural sector. Therefore, this study will play a significant role in reducing postharvest losses of vegetables in Nepal.

This study begins by discovering the causes of postharvest losses and finding the appropriate solution. Regarding the positive effects of technology on agriculture, we believe that farming methods in Nepal are the same as those in Japan 80 years ago and that Nepal can develop agriculture in the same way Japan experienced. Nepal could emulate modern Japanese tools and techniques. Also, this study can contribute to the agricultural development of Nepal by adding various analytical tools learned in Japan to advanced farm technology and agricultural knowledge.

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LIST OF ABBREVIATIONS

BDT	Bangladesh Taka
CBS	Central Bureau of Statistics
CH ₄	Methane
CO ₂	Carbon Dioxide
CRA	Climate Resistant Agriculture
DADO	District Agriculture Development Officer
DAO	Department of Agricultural Office
DHM	Department of Hydrology and Meteorology
EDS	Education for Sustainable Development
FAO	Food and Agriculture Organization
GDP	Gross Domestic Product
GHG	Greenhouse Gases
GON	Government Of Nepal
IME	Institution of Mechanical Engineers

INGO	International Non-Governmental Organization
IPCC	Intergovernmental Panel on Climate Change
IPCC	Intergovernmental Panel on Climate Change
IT	Information Technology
JICA	Japan International Cooperation Agency
MAFF	Ministry of Agriculture, Forestry and Fisheries
MOE	Ministry of the Environment
MOPE	Ministry Of Population and Environment
MPHD	Master plan for Horticulture Development
MT	Metric Tons
N ₂ O	Nitrous Oxide
NARC	National Agriculture Research Council
NASA	National Aeronautics and Space Administration
NGO	Non-Governmental Organization
NTNC	National Trust for Nature Conservation
PIK	Potsdam Institute for Climate Impact Research
POS	Point of Sale
SDG	Sustainable Development Goal
USA	United States of America
USD	United States Dollar
VDC	Village Development Committee
VDD	Vegetable Development Directorate
WFP	World Food Program

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Chapter 1 Introduction (1-4)

1.1 Rationale

In recent years arable land has been declining rapidly in infrastructure development, and it is challenging to provide food for the world's growing population. At the same time, the growing population and decreasing arable land are the biggest problems for food sustainability. The postharvest loss rate in developing countries is about 20 to 50 percent of the total production.¹ Resolving postharvest losses can help the economy and living standards of the farmers as well as aid in food sustainability. This study is based on all those factors that help find the proper solution to Nepal's postharvest loss of vegetables.

Fruits and vegetables play an essential role in our daily lives. It is called a preservative food rich in minerals and vitamins. Nepal's economy is based on agriculture, and Nepal is the largest producer of fruits and vegetables and plays a vital role in the national economy. Nepal has an excellent geographical area and topography for producing every kind of vegetable; most vegetables are available throughout the year. But the farmer's attention has yet to be paid to their commercial processing, and consumers also seldom accept processed foods. The contribution of processed foods to the national economy is meager; not giving attention to functional foods is a significant reason for vegetable loss after harvesting.

Losses can be reduced by bringing food processing industries into operation to reduce postharvest losses. The processing industry buys vegetables directly from farmers. In such a situation, its support can become a reality to increase farmers' income by reducing postharvest losses. The best utilization of science can give great results to the food processing industry.

Investment in the food processing industry and new projects will enable value addition of agricultural products, their longevity, and farmers to get better prices. Also, a better storage system will be available for the product, and a new alternative market will be open to the farmers.

¹Mopera, (2016).

Postharvest losses of vegetables occur at all points in the market chain area, from production to food on plates for consumption. Postharvest activities include harvesting, handling, storage, processing, packaging, transportation, and marketing. The loss of horticultural produce is a significant problem in the postharvest chain. It can be caused by various factors, ranging from growing conditions to handling at the retail level. The losses are not only a waste of food but also a waste of human effort, agricultural inputs, livelihoods, investments, and scarce resources such as water. This study aims to find out the actual causes of postharvest losses and provide appropriate solutions for them.

1.1.2 Structure of the thesis

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Chapter 2nd contains the "postharvest practice and losses of the vegetables." This chapter considered the causes of postharvest losses of vegetables from production to the consumer level and the harvesting technology of Nepalese farmers. Apart from this, government policies and agricultural implementations are also included. The study was conducted in Nepal (Kathmandu, Bhaktapur, and Lalitpur).

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The 6th chapter is "Conclusion and summary," This chapter focuses on the research's concrete results and the entire study's findings.

1.1.3 Research issue

The thesis focuses on research issues or questions identified during the research process. I have tried to determine the causes of the postharvest losses of vegetables, starting with farmers, then the interaction of farmers and traders, and finally, examining marketing systems.

1) How much do farmers know about their farming profession?

The cultivation method has a direct impact on the product's health. Among other things, knowledge of diseases, pests, and germs in the agricultural system plays a vital role in postharvest loss.

2) How do farmers access the market and traders access producers, and in the meantime, where occurs postharvest loss?

Postharvest losses in most developing countries occur in marketing channels; this study helps to find out the real cause of postharvest losses in market channels.

3) How much have the farmers benefited from the government agricultural subsidy?

Nepali farmers are cannot manage agricultural implements, irrigation, and roads excess; government assistance is indispensable in such cases. This study explores the Government of Nepal's agricultural investment and how farmers have benefited.

In the fiscal 2021\22, the total budget for agriculture was USD 45.90 billion. In comparison, in the budgetary year 2021\21, USD 40.41 billion, which means the government of Nepal annually invests a colossal amount in the agriculture sector to improve the agriculture industry. But a survey study found that only a few farmers benefit from it. Farmers should have benefited from the budget allocated in the agricultural sector, but in real life, it is not happening, and the relevant agencies should monitor regularly.

4) How does climate change play a role in postharvest losses, and how much are farmers aware of this?

Rising temperatures due to climate change are a significant challenge in marketing channels for farmers and suppliers in developing countries. Lack of suitable roads for transportation, refrigerated vehicles during supply, cooling facilities during storage, etc. The study focuses on what methods can be used to solve the problems.

5) In developed and developing countries, what are the differences in cropping methods, agricultural education of farmers, government agricultural regulations, government support for agriculture, supply chain systems, consumer behavior, etc.? Also, this study focuses on how it is possible to implement the agricultural system of Japan, a developed country, in Nepal.

6) The study focuses on where, how much, and why postharvest losses are occurring in Nepal, as well as what could be the problems and solutions.

To solve the problem of postharvest loss of vegetables in Nepal, this study has tried to solve the issues which could not be discovered and solved by the previous researchers keeping, given the result of the survey, which was done in a different place in Nepal and Japan.

Chapter 2 Postharvest practice and losses of vegetables in Nepal (4-41)

2.1 Introduction

Nepal is an agriculture country almost 66 percent of peoples directly engaged in farming²and indirectly more than 80 percent peoples are involving. Agriculture is the backbone of the national economy, means livelihood for most of the population, and is the primary source of gross domestic product (GDP), income, and employment opportunities for Nepal.³Total area covered by vegetable is 284,134 ha, production is 3,859,492 (2016/2017) and yield (kg/ha) 13,992 (2015/2016).⁴ The development of vegetables in Nepal started during the early forties.⁵Nepal's various topographic features and climatic conditions permit the successful production of many vegetables. There are more than 247 cultivated vegetable crops, of which more than 50 are common in Nepal.⁶The main vegetables grown are cauliflower, cabbage, radish, road leaf, mustard, carrot, peas, beans, chili, okra, brinjal, onion, cucumber, pumpkin, bitter gourd, and bottle gourd. Cauliflower has occupied the first position in area and production, followed by cabbage, radish, and tomato.⁷

The estimated postharvest losses of Nepal are approximately 20-50 percent⁸. Some of the researchers are introducing the major of the vegetable losses in the wholesale market⁹ but I'm not satisfied with them. I found the significant losses of the vegetables on the farmer's side; they only observed the wholesalers and forgot the losses on the vegetable growers and retailers' sides. Harvesting losses have been noted in economic matters to farmers, retailers, and wholesalers. My field survey shows farmers are more affected than wholesalers and retailers. It doesn't mean they are not suffering, but the postharvest loss ratio is more significant on the farmer's side than on wholesalers and retailers.

²Khanal, et al. (2021).

³Data from Tuladhar (2018).

⁴In Nepal fiscal year starts from July and ends the next June.2015/2016 means period between July 2015 and June 2016.

⁵Awasthi (2007). pp. 20-25.

⁶Awasthi (2003).

⁷see, Vegetable Development Directorate (2010).

⁸Gautam and Bhattari (2006).

⁹Devkota, et al. (2014).

The seen or hidden factors are responsible for the postharvest losses on the farmer's side. Lack of agricultural education and market is the primary cause of postharvest losses on farm sites. Nepal is a geographically deprived country, and there are many areas where traffic is often disrupted throughout the rainy season. In such a situation, farmers are forced to throw away their produce due to a lack of storage facilities.

An unhealthy market channel is another cause of loss at the farmer's site. Nepal and India's border is open. For this, Indian farmers are getting benefits because Indian farmers provide vegetables at a lower price than Nepalese products, so Nepalese farmers cannot compete with Indian prices. Farmers cannot sell, so they have to throw away their products or sell at a lower price. Sometimes they are not even able to cover the investment.

An unstable government is also playing a significant role in postharvest losses. There have been more than 20 strikes in a year by different political parties in Nepal, badly affecting the market channel. Sometimes the strike will last for more than a week, so it is conceivable that there will be complete wastage where there is no storage facility available on the farm produce at the farming level.

In an overview of postharvest loss surveys in Nepal and Japan, postharvest losses in both data are higher on the farmer's side than on the other. But the factors of casualties are slightly different; Losses on the farmer side in Nepal were 11 percent, where 5.0 percent was during harvesting and 6.0 percent during packaging. In the case of Japan, the losses were 7.5 percent on the farmer's side, 2.5 percent during harvesting, 1.0 percent during packaging, 3.0 percent during the picking process, and 1.0 percent during the loading and unloading process and related factors.

The survey found that Japanese farmers were well established and managed regarding their farming profession. Advanced harvesting equipment, harvesting method, etc., are the significant factors in reducing postharvest losses on the Japanese farmer side.

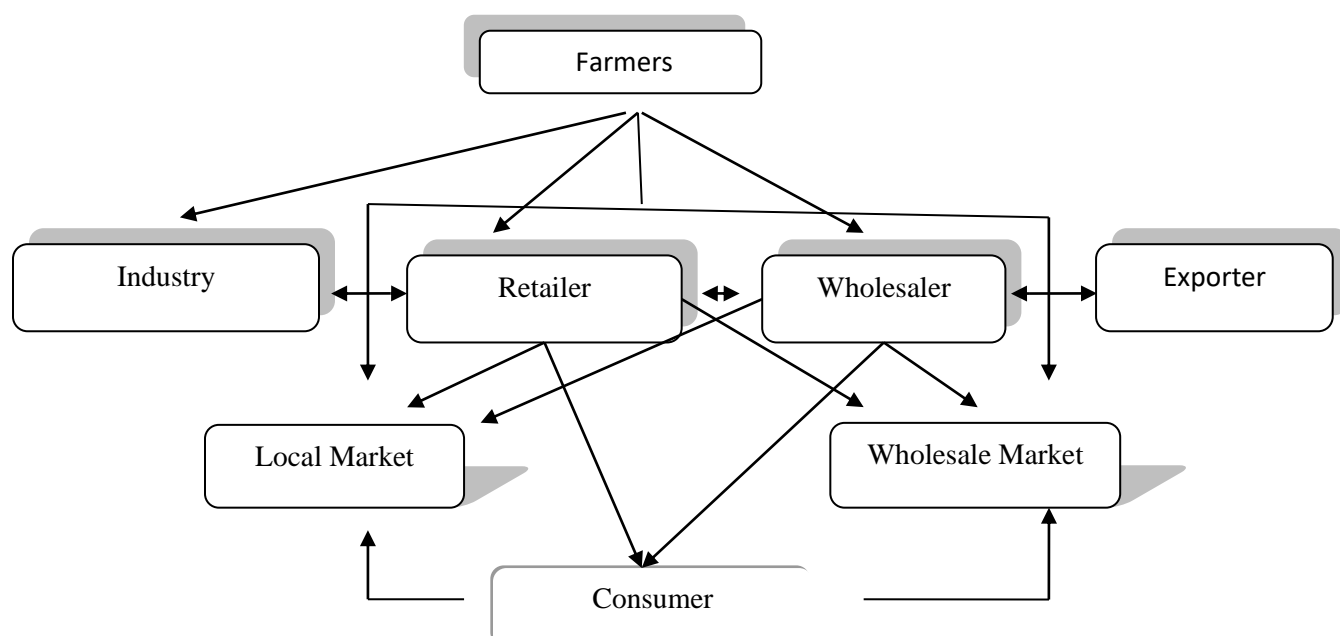


Figure: 2.1 Vegetable distribution channel system of Nepal, Source: By authors

Most of the developing country's farmers are suffering from the problem of postharvest losses. Behind this issue, there are various factors; in my field survey, very few Nepalese farmers know farming mythology and knowledge of diseases. They have been producing the same kind of vegetables for decades. They do not have any idea about the effeteness of global warming, which can be the possibility of declining the quality of the product; farmers are not acquainted with the hybrid product and modern technology.

The transportation and the caring method and technology also affect the enormous number of postharvest losses; in this matter, Nepal is very far behind in advances of technology; in the survey area, I hardly found advanced harvesting equipment and technology. Farmers have been

using traditional ways such as bamboo baskets to care for the food and plastic baskets to store the production; also, we do not have cooling facility vehicles to transport the vegetables. Lack of a proper warehouse is also a big problem in Nepal; Nepalese farmers have to sell their cultivated food at a particular time and period; otherwise, food becomes surface moisture and is damaged. Nepal is not meant to be not improving the agricultural sector, but the Nepalese agricultural industry is not developing as they are supposed to be.

Along with the economic benefits of the vegetable production business, vegetables are also beneficial for health. They are the primary source of nutrients such as vitamin A and C, potassium, folic acid, dietary fiber, etc. A diversity of vegetables is grown for their nutritional value, taste, and cuisine. Global production was 965.65 million tons in 2010 and continues to grow to meet ever-increasing consumer demand. China is a significant producer with about 549 million metric tons, followed by India with about 128 million metric tons of fresh vegetables. In the United States, California was the largest producer of fresh market vegetables in 2014.

Even though there is increasing interest among farmers and a significant increase in production, Nepal is not independent in vegetables. Nepalese farmers produce about four million tons of vegetables annually and import about three million tons, mainly from India and a similar quantity from other countries.¹⁰ This data shows a weak market channel because a lot of vegetables are dumped in the rural areas of Nepal, and farmers in rural areas do not have access to the market. On the other hand, the demand of the Nepalese market is not being met by Nepalese production.

Global production of vegetables has more than doubled in the last quarter, and the trade value of vegetables has more than doubled compared to cereals. The economic and productivity growth is not enough to eliminate hunger and provide vegetable sufficiency within the period.¹¹

Nowadays, people are conscious about their health, becoming more educated day by day. The brevity is also one of the reasons for increasing the demand for vegetables. There is a rapid increase in recognition of the health benefits of vegetable consumers. The vegetable farming

¹⁰Team,C.N (2020).

¹¹FAO (2010).

sector has a lot of potentials to get a very handsome income source. Due to the increase in population, demand also increases, and there is also a tendency to be vegetarian. It also helps in increasing the demand for vegetables. In 2016, more than 1.2 billion tons of vegetables were collected worldwide. The world average annual growth average for South Asia is 3.6%. In comparison, vegetable production is 2% (around 2.9% in 2006 and 2016). China is the largest producer of vegetables, with 52% of the world's production, followed by India (14%). Nepal contributes 0.3% of the yield to Asia.¹² A lot of agricultural land is abandoned in Nepal. Nepal could contribute more vegetables to the global market if those lands are cultivated.

Vegetables are cultivated in only 7.3 percent of the total cultivable land in Nepal. The consumption of vegetables has increased from 60 kg to 105 kg in the last two decades. If postharvest loss of vegetables can be controlled it could be possible to fulfill a certain percent of the market demand.¹³ It is more difficult to increase production than to reduce postharvest losses, so finding suitable solutions is necessary.

Population growth and increase in consumption rate define a great chance to get economic benefits from vegetable farming. The climate of Nepal is diverse, allowing us to grow a variety of vegetables from different regions. Trade with India accounts for more than 70 percent of Nepali vegetable market. That is, Nepali farmers cannot fulfill the demand of the vegetable market. Also, due to market rates and other kinds of issues, they cannot compete with Indian production.

On the other hand, in rural areas, farmers' products are not available from the market; Due to a lack of market facilities, they have to stop their production. Generally, markets are far away from this area, and transportation costs and postharvest losses are incredibly high. If the Nepalese government can build a transport road in that area, it will help improve the economic and social status of the farmers.

Table No. 2.1 Area of Commercial Vegetable Production major district of Nepal

¹²Team (2010).

¹³Vegetable Development Directorate (2010).

District	House hold	Total population	Area hectare (ha)	Production	Yield/ha
Kavre	80,720	381,937	9,699	133,678	13,782
Dhading	73,851	336,067	5,925	75,458	12,735
Lalitpur	109,767	468,132	2,476	48,630	19,641
Bhaktapur	68,636	304,651	3,243	58,911	18,165
Makawanpur	86,127	420,477	2,500	47,967	19,187
Kathmandu	436,344	1,744,240	3,030	39,248	12,955
Nuwakkot	59,215	277,471	3,812	3,812	9,473
Sindhupalanchok	66,688	287,798	3,418	35,539	10,398
Gorkha	66,506	271,061	2,025	35,186	17,376
Dolakha	45,688	186,557	1,782	19,553	10,976

Source: Commercial vegetable production major district of Nepal, Government of Nepal Ministry Agriculture Department (2014)

Data shows that the production area of Kavrepalanchok is higher than other districts, but the yield per hectare is high in the Lalitpur district.

Reducing postharvest losses ensures that every inhabitant of our planet has enough food, both in quantity and quality.¹⁴ Postharvest losses are relatively high in many Asian countries because of the inherent difficulty of collecting and transporting small quantities of produce from many small farms and collecting them in sufficient amounts for efficient domestic marketing or export. Even if large shipments can be collected together, the product is often highly variable in size and quality, so it is complex to implement a standardized grading and storage process. In tropical and subtropical countries, hot, humid climates add more stress and accelerate the decay of tropical produce. The need for improvement is demonstrated by the fact that in developing countries with poor infrastructure and marketing facilities, postharvest losses of fresh produce are estimated at

¹⁴Bourne (1986). pp. 1-16.

20–50%.¹⁵ Bhatpara's suggestion is worthwhile, but Bhattarai needed to explain how those suggestions might apply to the Nepalese scenario.

2.1.1 Statement of problem

The postharvest sector includes all points in the value chain, from production in the field to when the food is placed on the plate for consumption. Postharvest activities include harvest processing, storage, treatment of sprout inhibitors, sanitation procedures, packaging, transportation, and marketing.

Every year, the government of Nepal focuses on the commercialization of vegetables. Regardless of the great potential of production in Nepal and the government's continuous efforts, vegetable farmers are facing various problems, including marketing information, transportation facilities, proper education on agriculture, hybrid seed and product, postharvest techniques, and knowledge about postharvest vegetable losses, etc., Most of the rural areas farmers are not acquainted with the scientific technique cultivation, knowledge about the land and environment, the market is very far from the production area lack of the road and suitable transportation vehicles they are facing a lot of postharvest losses problem. Farmers are facing various kinds of obstacles until they are sold their products. I didn't find the farmers are aware of the possibilities of increasing yielding capacity in the survey area.

Horticultural crop loss is a major problem in the postharvest series. Loss can be due to various factors, ranging from growing conditions to handling at the retail level. The damage is not only wastage of food but also a waste of human effort, agricultural inputs, livelihoods, investments, and scarce resources like water. However, it is challenging to measure postharvest losses in horticultural crops.

Although the exact position of loss after harvesting of vegetables has not been determined, it is important to illustrate the position and effects of the amount spent by government and non-government organizations. In order to get an accurate picture of the post-harvest condition of the study area in a colonial manner, the purpose of this study is to answer the following questions:

¹⁵ See, Bhattarai (2018). p. 458.

What is the post-harvest deficit situation of vegetables? What is the problem faced by farmers, wholesalers and retailers? What were the post-harvest activities for vegetables appointed by farmers, wholesalers and retailers?

2.1.2 Justification of study

Despite Nepal's excellent crop-growing potential, many vegetable products are imported every year. More than three-fourths of Nepal's livelihood is based on agriculture. About 80% of the population is engaged in agriculture. Most of the farmers are involved in agriculture to sustain their livelihood.

Nepal can save thousands of tons of vegetables by preventing Postharvest losses. More reduction of losses is more economical rather than to increase in production. It is tough to grow a 20 percent yield rather than reduce 20 percent of the loss. Thus, the supply of vegetables can be significantly increased without bringing additional land inputs for the production.¹⁶In most cases, farmers are unaware of Postharvest technology; hence they suffer from postharvest losses in vegetables and do not get a reasonable price for their product. This study was undertaken to provide the status of Postharvest losses under the study area. Findings help to adopt new techniques of postharvest practice to reduce the losses. It will be beneficial for the farmers, wholesalers, and retailers.

2.1.3 Objectives

General Objectives

The study's general objective was to show the postharvest loss of vegetables and find a suitable solution.

Specific objectives

1) To know the actual position of postharvest losses in the supply chain and to find suitable solutions to reduce the losses.

¹⁶Bhattarai & Gautam (2006). P. 37-41.

- 2) To identify the postharvest actions of vegetables adopted by the farmers, find out the major factors of loss on the producer side, and provide suitable solutions.
- 3) To meet unresolved or missed issues on postharvest losses across the supply chain.
- 4) To find out the difference in postharvest losses between developed and developing countries. This will help in finding pioneering solutions for Nepal.
- 5) To identify where the postharvest loss rate is high and the reasons behind it.

In order to reduce postharvest losses, modern methods or principles have been innovated in many other developed countries. Another objective of this study is to evaluate whether or not those methods are applicable in Nepal's scenario.

Scope of the study

Despite farmers' comprehensive coverage of agricultural land, they are not generating any real profit due to some loss in the supply chain from production to market. This is due to the lack of postharvest handling techniques for the long-term storage of vegetables. Under proper treatment of postharvest losses in packaging, transportation, retailing, etc., production can be increased to a substantial extent.

The study was conducted in different regions of Nepal (Kathmandu, Bhaktapur, Lalitpur, Kavrepalanchok, and some hilly districts such as Syangja, Palpa, Terai district Kapiabastu and Rupandehi and Himali district Gorkha, etc.). It mainly focuses on post-harvest losses of various types of vegetables. The study will help the agencies concerned to identify the needs and problems of farmers, suppliers, and wholesalers. Despite extensive agricultural land coverage, farmers are not generating any real profit due to some loss in the supply chain from production to market linkage. The study is helpful to NGOs, INGOs, researchers, students, policymakers, and related stakeholders working in horticulture and farmers, wholesalers, and retailers.

2.1.4 Limitation of the Study

The limitations of the study were:

- The number of farmers, suppliers, and retailers interviewed in this study is just a tiny sample of the total number.
- Limited secondary information relevant to this study.
- As researchers, students have limited time and budget to investigate all aspects of a large population.
- Due to COVID 19 this study has not been able to conduct the field survey as expected.

2.2 Literature Review

This chapter reviews the recent literature under various headings related to this study, as little information is available on post-harvest losses in the vegetable supply chain. The relevant literature was briefly reviewed under the following titles and subheadings.

2.2.1 Postharvest losses of Vegetables

The worldwide postharvest losses

Postharvest losses of vegetables originate from poor pre-harvest and postharvest management, including bad handling of produce during transit and storage, leading to a partial or total loss in product quality.¹⁷ The knowledge of pre and postharvest management plays a significant role in the losses; the situation in Nepal is also similar, and related bodies need to pay more attention to managing the supply chain. So, it is possible to reduce losses by making a suitable management system, as Prusky (2011).

Vegetable waste often referred to in the literature as loss "spoiled," is a significant concern related to postharvest losses. This type of loss is related to products intended for human consumption occurring at the end of the supply chain due to retail and consumer behavior.

There are significant postharvest losses on the farmer side in Nepal; the ratio is 11 percent out of 26. About 45 percent of postharvest losses are on the farmer's side. Postharvest losses of

¹⁷Prusky (2011). pp. 463-474.

vegetables vary high, with losses of up to 50 percent or more in developing countries.¹⁸ They are a standard feature of supply chains in these countries, often represented by hot and humid tropical climates and a lack of knowledge, techniques, and facilities in production operation and processing. The hostile environment and poor management, coupled with the perishable nature of vegetables, significantly reduce the profitability and efficiency of supply chains.¹⁹ The approach of Weinberger et al. (2011). is strictly applicable in the case of Nepal. But the biggest question is how these problems can be solved.

China is the largest agricultural producing country globally and is introducing very advanced technology in the agriculture sector; Nevertheless, China is facing a severe problem of postharvest losses. Postharvest losses are still painful, with over 35% percent in China.²⁰ The significant losses occur because of the deficiency of proper storage facilities during transportation.²¹ Like China, Nepal also has a poor transportation system and a lack of proper storage facilities. The Nepalese vegetable market channel suffers badly, and the loss rate is very high. But if we look at developed countries like Japan, Japan suffers a shallow loss during transportation because of the well-managed market channel and advanced transport vehicles. In the present age, China has been addressing the very advanced technology in the farming sector; most farmers are adopting modern tools and cultivating hybrid products.

India is the most advanced in addressing the problem of postharvest losses and estimating actual losses. The estimated postharvest losses of vegetables are around 30-40 percent.²² The postharvest loss rate of vegetables in India is also about the same as in Nepal, but the drivers of losses are slightly different. Nepal has not developed transportation roads and vehicles like India. As well as, India has so many promising industries. Vegetables have the potential to be a raw material for functional foods. Also, Indian farmers are not facing the same market shortage situation as their counterparts in Nepal.

¹⁸Kader(2005). pp. 2169-2176.

¹⁹Weinberger, et al. (2011). p. 357.

²⁰Feng (2000).

²¹Feng(2000).

²²Hegazy(2013).

India is the world's second-largest vegetable producer, with an annual production of over 150 million tons growing at a compounded annual rate of 5-6 percent. The All India Coordinated Research Project on Post-harvest Technology conducted a national study to obtain reliable loss estimates for all production and distribution phases for major crops. The total average postharvest losses for vegetables were estimated at 7-8 percent for cabbage, cauliflower, and onion, and 13 percent for tomato. The Associated Chambers of Commerce and Industry of India reported that about 30 percent of vegetables and fruit are lost after harvest, worth a total of over 2 trillion INR per year (over 33 billion USD), due to a lack of storage and processing facilities and indifferent attitudes towards tackling the problem.²³ Like Hegaji's (2013) view, Nepal also loses due to a lack of storage facilities for large quantities of vegetables; farmers and wholesalers are more affected in summer seasons.

In Turkey's third-largest vegetable producer country, Turkey's postharvest losses of vegetables are 25 percent, and the highest rate of around 10 percent of losses occurs on the retailer's side.²⁴ In the field survey, postharvest losses in Nepal have been found to be the highest rate on the farmer's side, but according to Azabagaogul(2018), Turkey's have the highest rate of losses on the retailer side. Different channel systems and postharvest losses have different rates depending on the countries. Harvest timing and careless product handling lead to food waste in the supply chain.

Iran is also the seventh horticultural producer with the highest postharvest losses in vegetables; it accounts for 30-50 percent of postharvest losses in Iran each year.²⁵ Iran is moving vegetables growing in the greenhouse. Irani Farming technology and method are far more developed than in Nepal, so we can learn from Irani farmers how to cultivate vegetables with outstanding taste in the greenhouse. It is helpful for the farmers to produce off-season products and get the high price of the market rate.

In Bangladesh, postharvest losses of vegetables were reported to range between 18–44 percent, which is equivalent to an average annual loss of over 2 million tons of production worth about

²³Hegazy (2013). P. 3.

²⁴Azabagaogul(2018). pp. 62

²⁵Jowkar, et al. (2005).

3,392 million BDT (US\$45 million).²⁶In a case study in eggplant(brinjal), the postharvest loss at the farmer level is 13 percent in Bangladesh.²⁷ Comparatively, losses at the farmer level in Bangladesh are higher than in Nepal.

The estimated postharvest loss of vegetables in Nepal lies in the range of 20-50 percent.²⁸According to the Gautam & Bhattarai trying to show data of the postharvest losses of vegetables, they haven't indicated which side is the primary leakage; commensurate with my field survey, I found the main postharvest losses occurring on the farmer's side. Farmers can reduce those losses using modern technology such as assessing the maturity, avoiding injury while packaging and transportation process, used by the cooling warehouse storage, and caring while uploading and unloading process. Etc.,

Postharvest losses of vegetable in supply chain

Vegetables are among the perishable food items. Approximately 650 metric tons of vegetables arrive at the wholesale market daily in Kathmandu Valley. On average, 15 to 25 metric tons of vegetables are found to be damaged and discarded.²⁹This means 2.3 to 3.8 percent of postharvest losses occur during the transport phases. This loss occurs only on wholesale-level transportation, followed by another loss on transportation during the distribution period. Kandel's (2014) study also showed that losses during transportation are high in Nepal. It is estimated that in 2008 there were 19.5 million tons of food lost at the retail level in the United States; of this, 12 percent was attributed to fresh vegetables and another 4 percent to processed vegetables.³⁰Based on the US Department of Agriculture, Economic Research Service, it could be estimated that postharvest losses in developed countries are higher at the retail level. Farmers of developed countries are much more aware of food losses, and other factors such as developed infrastructure, farming technology, and market channel also affect the losses.

²⁶Hssan (2010). p. 21.

²⁷Khatun, et al. (2019). pp. 454–460.

²⁸Gautam, et al. (2017). pp. 37-41.

²⁹Kandel (2014).

³⁰US Department of Agriculture, Economic Research Service (2010).

Furthermore, USA food losses at the consumer level for that same year were approximately 37.7 million tons, and of this, fresh and processed vegetables accounted for 14 percent and 6 percent, respectively.³¹

Nepal produces about 3 million tons of vegetables from 235,100 hectares, and postharvest losses generally range between 25 to 30 percent in a year.³² Tomato had the highest losses (33 percent), followed by cauliflower (14 percent), cabbage (13 percent), green peas (10 percent), and beans (7 percent).³³

Losses were measured at different stages in the supply chain. For tomatoes, losses are:

- Ten percent at the farm gate.
- Five percent at the collection center.
- Eight percent at the wholesale market.
- Ten percent at the retail markets.

Losses were due to a lack of proper handling, storage, and transportation; in most cases, there was no grading. Losses borne by tomato farmers, collectors, wholesalers, and retailers differed only slightly from each other. They were 5-7 percent, while cauliflower collectors and wholesalers had higher losses than farmers and retailers. Losses borne by farmers were mainly due to pre-harvest insect and disease damage, while those held by collectors, wholesalers, and retailers were due to deficiencies in packaging, storage, and transportation.³⁴ In the Terai districts of Kapilvastu and Banke, postharvest losses of tomato and cauliflower were estimated at 25 percent and 21 percent, respectively.³⁵ Humidity is relatively high in Terai than in other parts of Nepal, so it is challenging to protect vegetables. Nowadays, due to climate change, the temperature is increasing in such a situation the problem is becoming more challenging. So, it is essential to build a refrigerated installed warehouse to control postharvest losses. In vegetables,

³¹Ibid.

³²High value agricultural product (2011).

³³Bhattarai (2000).

³⁴Agribusiness promotion and Marketing Development Directorate (2013).

³⁵Agribusiness Promotion and Statistics Division (2011/12).

15-30 percent loss has been reported at different stages, while there is 5-10 percent loss during loading, unloading, and transportation, 10-20 percent loss during wholesale and retail marketing.³⁶The total loss during transportation of tomatoes from Syangja (mid-hills district of Nepal) to Butwal (Terai markets) was around 23 percent. Similarly, the mechanical loss was found to be 35 percent during the transportation of tomatoes from Kapurkot, Salyan (mid-hill), and Lalbandi (Terai) to Kathmandu.³⁷The study showed that the rate of vegetable loss varies according to the nature of the road. Therefore, it is also necessary to pay attention to road improvement to reduce the postharvest losses caused during transportation.

The Master plan for Horticulture Development (MPHD, 1991) is considered conservative weight-based losses of 25 percent in vegetables and 32 percent in potatoes, including tuber seed. Werner et al. (1991) showed physical losses of 22.85 percent in tomatoes, 15.84 percent in cabbage, and 12.85 percent in cauliflower, besides an additional of 5-10 percent of moisture losses is reported from specific research conducted by FAO,³⁸ in Terai, Kalimati market and retail shops at Kathmandu.

The Marketing Development Division (2000) conducted a study for loss during transportation from Bhairawa Nepal to Gorakhpur, India in cabbage and potato, 17.39 percent and 15 percent, respectively. The marketing development division assessed loss during transport of Cauliflower and cabbage from Birgunj, Nepal, to Patna, India, which was 18.75 percent and 19.23 percent, respectively.³⁹Postharvest losses on transport fluctuate in the case of Nepal, as it varies from place to place due to geographical diversity, with government stability and weather playing a significant role in transport.

Postharvest losses of vegetable in Nepal

In Nepal, subsistence agriculture remains a prime occupation; about 80% of the agricultural households are subsistence-based. The total cultivated area of the country is 3.09 million hectares. Different vegetables are grown all over the country but mainly as minor crops. The vegetable crops occupy 7.3% of the total cultivated agricultural land, which indicates the

³⁶Kaini (2000). p. 218.

³⁷Ibid.

³⁸Food and Agriculture Organization(2019).

³⁹Agribusiness promotion and Marketing Development Directorate (2013).

potential for increasing vegetable production in the country.⁴⁰The study showed that although the cultivable land is still under-utilized in Nepal, more than 8 million Nepalese youth are abroad searching for jobs. Many reasons account for this; an important reason is that Nepali youth are not seeing their future in the agricultural profession. If the government can create a suitable environment for this, the youth will be eager to join agriculture. It is possible to have a well-managed supply chain and market access which will be the backbone support to control postharvest losses. Also, it is possible to attract the younger generation to innovate modern farming techniques and equipment. Postharvest losses can be reduced by involving the younger generation.

High postharvest losses are caused by the invasion of fungi, bacteria, insects, and other organisms. Microorganisms attack fresh produce and spread rapidly because the crop lacks many natural defense mechanisms and contains many nutrients and moisture to support microbial growth. Postharvest decay control is becoming a more difficult task as the number of insecticides is falling rapidly as consumers worry about increased safety. The estimated loss of vegetables is about 30 percent from diseases in tropical countries.⁴¹Rising temperatures due to climate change are becoming a major cause of disease and insects, which the authors do not mention. Most of the warehouse in Nepal there is not refrigerator facilities so insects are much more spares in hot temperatureso vegetables quickly spoil.

Lack of essential tools and equipment, lack of maintenance, and lack of spare parts make vegetables the worst hit. Inadequate infrastructure and advanced production technology are major barriers to food security for many developing countries, such as Nepal.

The vegetable sector contributes more than Rs. 36 billion of value in the country, with cauliflower, tomato, and cabbage as the lead contributors with Rs values. 4.9 billion, Rs. 4.4 billion and 2.8 billion, respectively.⁴²The postharvest loss is more pronounced in vegetables because of their perishable nature. The lack of proper postharvest technology causes losses in weight and quality, resulting in lower market value. It is of prime importance that the vegetables

⁴⁰Vegetable Development Directorate (2010).

⁴¹Gautam, et al.(2006) .p. 37-41.

⁴²Central Bureau of Statistics (2010).

we produce are of high quality and fetch high prices during selling. Due to the highly perishable nature of vegetables, it becomes challenging to maintain the quality during marketing. However, proper handling, storage, and better transportation can minimize losses. Awasthi (2003) reported that more than two hundred vegetable species are grown in different climatic zones of Nepal. Of these, fifty species and their varieties are produced commercially. Tomato, cauliflower, cabbage, cucumber, onion, and chili are the primary off-season vegetables of Nepal. Among them, the cultivation of tomatoes, cauliflower, and cabbage is the most popular and the most profitable. During the survey, farmers said that protecting the tomato is more complicated than other vegetables. Hence, if it analyzes the entire supply chain, then the losses of tomatoes are higher than other vegetables. So, the amount of profit could not reach as expected.

2.2.2 Government subsidies at farmer, wholesaler and retailer level

In the fiscal 2021\22, the total budget for agriculture was USD 45.90 billion. In comparison, in the budgetary year 2021\21, USD 40.41 billion, which means the government of Nepal annually invests a colossal amount in the agriculture sector to improve the agriculture industry. But a survey study found that only a few farmers benefit from it. Farmers should have benefited from the budget allocated in the agricultural sector, but in real life, it is not happening, and the relevant agencies should monitor regularly.

Out of the total 60 respondents, 31 respondents benefited from government subsidies. Of which 67.7 percent are farmers, 12.9 percent are suppliers, and 19.35.7 percent were suppliers. Out of the total 67.7 percent, 46.7 percent of farmers received some assistance from government subsidies, such as farm equipment and hybrid seeds, at affordable prices, with 21.2 percent benefiting from agricultural training. Pesticides were provided to 22.3 percent of the farmers, and the remaining 9.8 percent got all the above facilities. In the case of the wholesaler's side, they receive pesticides, mouse-trapping machines, crates, training, etc.; the retailer side has only crates and bamboo baskets.

Table No. 2.2 Government subsidies at farmer, wholesaler and retailer level

Categories	Illiterate		Primary level		Secondary level		Above high school		Total	
Farmers	2	[100.0] (9.5)	9	[75.0] (50.0)	8	[72.7] (38.1)	2	[33.3] (9.5)	21	[67.7] (100.0)
Suppliers	0	[0.0] 0.0	0	[0.0] 0.0	2	[18.2] (50.0)	2	[33.3] (50.0)	4	[12.9] (100.0)
Retailers	0	[0.0] 0.0	3	[25.0] (50.0)	1	[9.1] (16.7)	2	[33.4] (33.3)	6	[19.35] (100.0)
Total	2	[100.0] (6.4)	12	[100.0] (38.7)	11	[100.0] (35.4)	6	[100.0] (19.35)	31	[100.0] (100.0)

Source: Field survey, 2019.

The survey found that the education of respondents is directly impacting to get government subsidies. For illiterate farmers, only two people benefited; if we see the primary level, 9 out of 13, and the secondary level, 8 out of 8 farmers were getting government subsidies. Similarly, in the case of suppliers, none of the illiterate is getting any assistance, and two out of three suppliers benefited. The issue of retailers is also similar; the respondent's education directly impacts getting the subsidy.

Government assistance is essential to reduce postharvest losses. Farmers in developed countries farmers, retailers and wholesalers are benefit from government policies and other kinds of assistance. But in the case of developing countries like Nepal government needs to pay more attention to postharvest losses. Every year government allocates massive amounts of budget for the agriculture sector. Still, there is a vast gap between the economic and Inspection departments, of which allocated budgets are leaking and have yet to reach where they should be.

2.3 Materials and methods

2.3.1 Study area

The study was conducted in different districts in Nepal (Kathmandu, Bhaktapur, Lalitpur, Kavrepalanchok, and some hilly districts like Syangja, Palpa, Nuwakot, Gorkha, and terai districts Rupandehi and Kapilvastu etc.). Nepal has a diverse geography, including hills and plains with adequate agricultural land. It lies on the southern slope of the Himalayan Mountain range. It is a landlocked country located between India to the east, south, and west and the Tibet

of China to the North. The survey was conducted in the Himalayan, Terai, and Mountainous regions of Nepal, which is new in the context of Nepal, so this study can provide critical data and factual factors of postharvest loss.

Map of the survey area

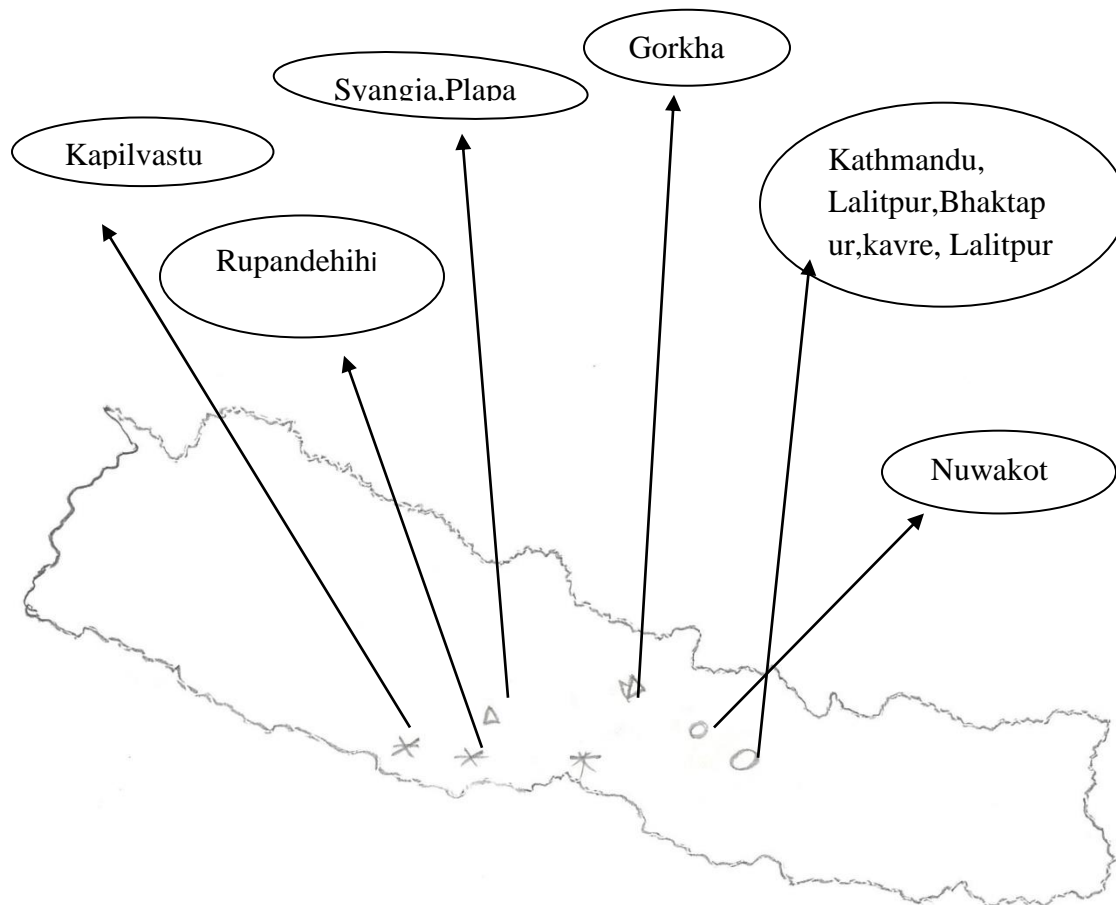


Figure: 2.2 Map of the survey area, Source: Handmade map

The questionnaire survey was conducted from September 27 to December 7 2019.

2.3.2 Basic statistics

Sampling was carried out by using the method of selected arbitrarily; the farmer's sample size was 30, which is the greatest among other respondents (suppliers, retailers) because farmers are the ones who produce a large number of vegetables, and loss occurred higher than suppliers and retailers due to the lack of knowledge about different Postharvest technology like optimum harvesting period, method of harvesting, lack of handling technology, lack of packaging materials, lack of storage facilities, etc. The study conducted 30 sample sizes for farmers/ producers among 60 samples. For the remaining 30 samples, 10 for suppliers and 20 for retailers. The target groups with their respective sampling size are shown in the table below. The target groups with their respected sampling size are shown in the table below. The study found that a large number of respondents in the age group of 41 to 50 are involved in vegetable cultivation.

Table No. 2.3 Number of respondents with their age variations

Respondents	<30		31-40		41-50		50<		Total	
Farmers	6	[60.0] (20.1)	7	[50.0] (23.3)	13	[54.2] (43.3)	4	[33.3] (13.3)	30	[50.0] (100.0)
Suppliers	1	[10.0] (10.0)	2	[14.3] (20.0)	4	[16.7] (40.0)	2	[16.7] (20.0)	10	[16.7] (100.0)
Retailers	3	[30.0] (15.0)	5	[35.7] (25.0)	7	[29.2] (35.0)	6	[50.0] (30.0)	20	[33.3] (100.0)
Total	10	[100.0] (16.7)	14	[100.0] (23.3)	24	[100.0] (40.0)	12	[100.0] (20.0)	60	[100.0] (100.0)

Source: Field Survey, 2019.

2.3.3 Interview with key informant

Various interviews regarding vegetable framing were conducted. I visited the DADO (District Agriculture Development Officer), DAO (Department of Agricultural Office), Postharvest directorate, (VDD) Vegetable Development Directorate, (NARC) National Agriculture Research Council, etc.

2.3.4 Source of the data collection

The study was supported mainly by collecting primary data and secondary data to a lesser extent. The primary data was collected from field surveys. Secondary data was collected by reviewing various published and unpublished documents relating to the study title.

Primary Data Collection

For primary data collection, a field survey was conducted in collaboration with questionnaires. The primary data source was obtained from door-to-door visits of vegetable growers, suppliers, and retailers.

Questionnaires

A set of semi-structured questionnaires was prepared to capture the nutrient deficiency, maturity index, various postharvest management activities, and harvesting methods of vegetables. In addition, general information about the respondents and their households, gender, education level, the government grant, age, reason for postharvest losses, harvest materials, etc., was also included in the questionnaire to know the respondents' socio-economic status. A set of semi-structured questionnaires was prepared before the data were collected from the field visits.

Secondary data collection

Secondary data is also used in this work where required. This information was collected from various sources such as publications of government agencies, such as the Ministry of Agriculture and Cooperatives and Agricultural Knowledge Center. Information was also collected from published and unpublished books, annual reports, and research papers.

2.3.5 Data processing and Analysis

The information collected from the survey was first coded and entered into the computer. Descriptive facts such as standard deviation, percentages, and frequencies will be used to process the data. Data entry and analysis are done using computer software packages such as Microsoft Excel. The analyzed data is then presented in tables, graphs, and pie charts.

2.4 Result and discussion

The research titled "Postharvest practice and losses of vegetables in Nepal". It is operated with the help of farmers, wholesalers, and vendors involved in the overall supply of vegetables. The significant results and conclusions obtained were presented in the following areas.

General Information of the respondents (Farmers, Retailers, wholesalers)

2.4.1 Farmers Profile

Age group of farmers

The age categories of the respondents were divided into four groups (below 30, 31-40, 41-50, and over 50 years). The study revealed that the majority of the farmers, 20.1 percent were in the age group of below 30 years, 23.3 percent were in the age group of 31-40 years, 43.3 percent were in the age group of 41-50 years, and 13.3 percent were above 50 years. Farmers in the age group of 41-50 are more engaged in vegetable production. It has been found that farmers in the age group of 41 to 50 years are more involved in farming.

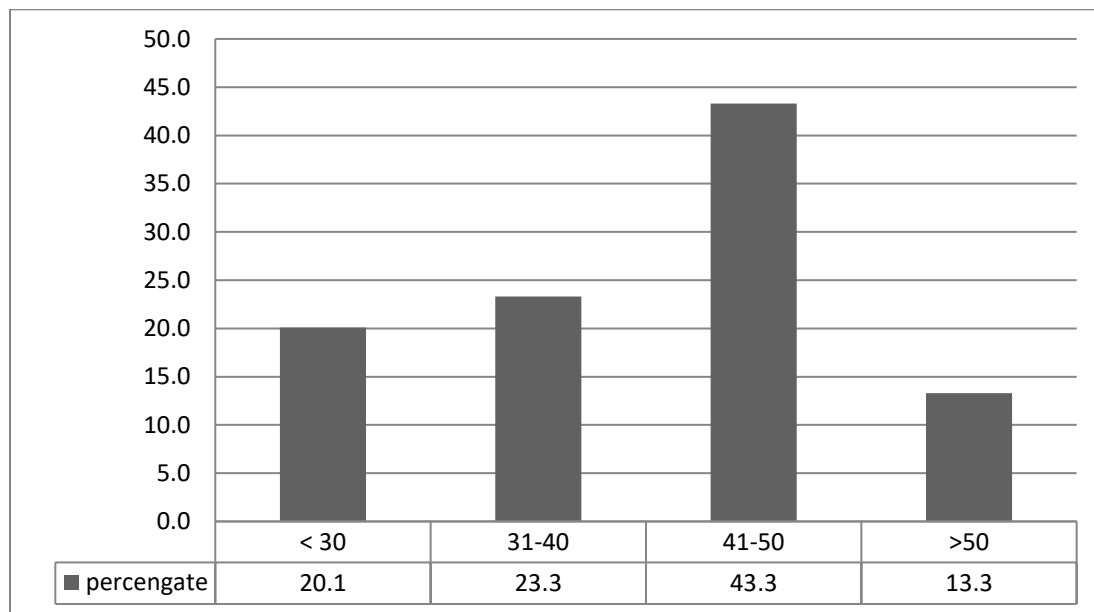


Figure: 2.3 Age group of farmers

Gender of respondents

Both male and female genders were found to be involved in vegetable production activities in the study area, but the participation of males was less than that of females. It was found that the majority of female respondents, 53 percent and 47 percent of male respondents, were active in discussions and conversations during the survey period. The result showed that males and females were almost equally engaged in vegetable cultivation. Other women were involved in household chores, and men were involved in skilled work. And in the survey, it has been found that farmers who have obtained primary-level education are more involved in the agricultural sector.

Table No. 2.4 Gender of respondents with their education status

Literacy Gender	illiterate	Primary level	Secondary level	Above high school	Total %
Male	17.49	18.55	10.6	6.36	53.0
Female	15.51	16.45	9.4	5.64	47.0
Total %	33.0	35.0	20.0	12.0	100

Source: Field Survey, 2019.

Literacy Status of the respondents

Most respondents (34.3 %) were educated to the primary level in the study area. Similarly, 23.3 percent of the respondents were found illiterate, 26.7 percent of the respondents had achieved secondary level education, and 6.7 % of respondents had achieved above high school certification. The other literate people were engaged in other higher-level jobs in an urban area, so illiterate people were involved in farming. The study found that the level of education of farmer's sides is relatively low compared with suppliers. This also may be a reason for the high postharvest loss rate in farmer sites.

Table No. 2.5 Literacy Status of respondents

Categories	Illiterate		Primary level		Secondary level		Above high school		Total	
Farmers	7	[63.64] (23.3)	13	[50.0] (43.3)	8	[50] (26.7)	2	[28.57] (6.7)	30	[50.0] (100.0)
Suppliers	1	[9.09] (10.0)	2	[7.69] (20.0)	4	[25.0] (40.0)	3	[42.85] (30.0)	10	[16.7] (100.0)
Retailers	3	[27.27] (15.0)	11	[42.30] (55.0)	4	[25.0] (20.0)	2	[28.57] (10.0)	20	[33.3] (100.0)
Total	11	[100.0] (18.3)	26	[100.0] (43.4)	16	[100.0] (26.6)	7	[100.0] (11.6)	60	[100.0] (100.0)

Source: Field Survey, 2019.

Information Land Production and Income

Information on land and production includes:

- Vegetable producing land.
- Production volume in a year.
- The production seasons.
- Average income from vegetables in a year.

Production Area of Vegetable

The field survey showed that the majority of respondents, 70 percent were small-scale (0.2ha) producers of vegetables. Similarly, 30 percent of farmers belong to large-scale (above 0.2 ha). The land holdings are very small, with an average size of 0.7 hectares,⁴³ but the majority of the vegetable farmers do not even have 0.7 hectares. So, they produced vegetables within the land available to them, which was comparatively small, and all the respondents cultivated only vegetables.

⁴³CBS (2019).

Table No. 2.6 Vegetable Production area of farmers

Scale of farmers	<30	31-40	41-50	50<	Total
Small scale (0.2 ha)	2 [33.3] (9.5)	5 [71.4] (23.8)	10 [76.9] (47.6)	4 [100.0] (19.1)	21 [70.0] (100.0)
Large scale (above 0.2 ha)	4 [66.7] (44.4)	2 [28.5] (22.2)	3 [23.1] (33.4)	0 [0.0] 0.0	9 [30.0] (100.0)
Total	6 [100.0] (16.7)	7 [100.0] (23.3)	13 [100.0] (40.0)	4 [100.0] (20.0)	30 [100.0] (100.0)

Source: Field Survey, 2019.

Distribution of Respondents according to their volume of production in a year

The farmers whose total vegetable production was up to 400 crates per year were considered small-scale producers; above 400 crates were moderate producers. Field information showed that 88.60 percent of farmers were small-scale producers in terms of volume of production, though, by land area, 11.40 percent of respondent farmers were large-scale producers by volume of production. However, large-scale cultivation reduces postharvest losses, but in Nepal, only a few farmers are farming on a large scale.

Table No. 2.7 Distribution of farmers according to their volume of production in a year

Range of production (crate)	Total production (crate)	Percentage (%)
Small-scale (up to 400 crate)	6,345	88.6
Large- scale (above 400 crate)	816	11.4
Total	7,161	100

Source: Field Survey, 2019.

Distribution of Respondents According to their frequency of production in a year

The frequency of vegetable production practices of farmers of Nepal varied from one to three times a year (Annually, Biannually, and Perennially)

Field information showed that 70.0 percent of farmers produce vegetables three times a year. Similarly, 26.67 percent had produced twice a year, and a minority of farmers 3.33 percent had grown vegetables yearly. The study found that education level directly impacts frequency production.

The farmers who produced three times a year were commercially large-scale producers in terms of land, the volume of production, and frequency of production as well. These category farmers applied farming techniques such as plastic tunnels and drip irrigation facilities where small producers had less knowledge of farming techniques.

Table No. 2.8 Frequency of vegetable production per year

Frequency production	Illiterate	Primary level	Secondary level	Above high school	Total
3 Times a year	2 [28.57] (9.5)	9 [69.23] (42.9)	8 [100.0] (38.1)	2 [100.0] (9.5)	21 [70.0] (100.0)
2 Times a year	4 [57.14] (50.0)	4 [30.76] (50.0)	0 [0.00] 0.0	0 [0.00] 0.0	8 [26.67] (100.0)
1 Time a year	1 [14.28] (100.0)	0 [0.00] 0.0	0 [0.00] 0.0	0 [0.00] 0.0	1 [3.33] (100.0)
Total	7 [100.0] (23.3)	13 [100.0] (43.3)	8 [100.0] (26.7)	2 [100.0] (6.7)	30 [100.0] (100.0)

Source: Field Survey, 2019.

Distribution of farmers according to their income from vegetable production annually

The information showed that 46 percent of farmers made income ranging from 10,000-50,000 which was significantly less than those who made income above 150,000. Generally, Nepali farmers do not keep a separate account of income from vegetable farming. So below is the table of the amount of money the farmers saved from selling vegetable after paying their household expenses.

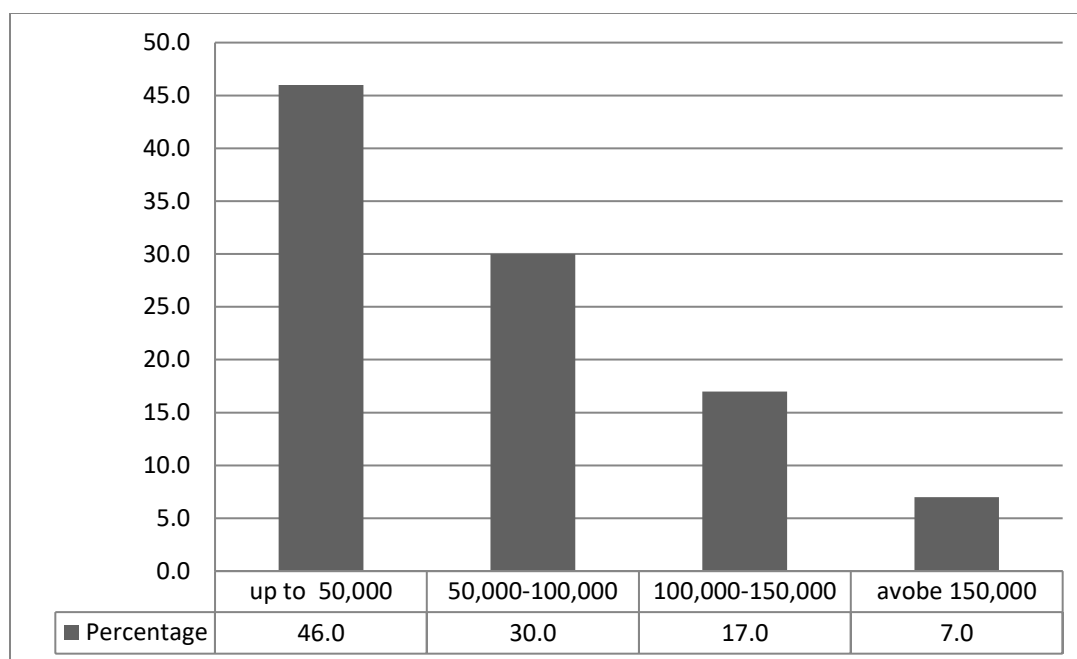


Figure: 2.4 Annually income of farmers, Source: Field Survey, 2019.

Losses of vegetable in farmer side

The losses during harvesting, handling, and packaging were observed to be excessive. Other damages were caused by entomology like fruit and shoot borer, aphids, whitefly, and pathological factors like yellow leaf curl, late blight, damping, etc.

Loss of vegetable during harvesting

As per the table below, the field information showed that 5 percent of losses occurred during the harvesting process by farmers in the field. These losses mainly included entomological such as aphids, fruit flies, white flies, and pathological factors such as yellow leaf curl, late blight, etc. Other losses were due to rough handlings and untimely harvesting of vegetables.

Losses of vegetables during packaging

In the case of packaging materials, most of the respondents used bamboo baskets (53%), whereas 36 percent and 11 percent used crate and plastic baskets, respectively. The total loss of

vegetables during packing was 6 percent, as shown in table 4. The information showed that the significant loss occurred during the packaging.

Physical losses were comparatively the significant losses that occurred in post-harvesting of vegetables. These losses factors include rough handling, bruising, and physical pressure, which destroy vegetables' shape and physiological structure. Studies show that packaging material also impacts postharvest losses; the losses ratio of farmers who use plastic bags is higher than bamboo baskets and crates.

Table No. 2.9 Distribution of farmers according to their use of packaging materials

Packaging material	No. of farmers	Losses during packaging (%)
Bamboo basket	16	53.3
plastic bag	3	10.0
Crate	11	36.7
Total	30	100.0

Source: Field Survey, 2019.

Loss during storage

After harvesting for a few hours, farmers stored their vegetables in an open field. The storage was not required as the suppliers came and collected the vegetables within a few hours of harvesting. Loss during storage was negligibly less, as reported by farmers during data collection.

In the survey area, 76 percent of farmers were small-scale, and postharvest losses were slightly higher on the small-scale farmer's side than on the large-scale farmer's side.

Table No. 2.10 Loss in farmer's side.

Types of losses in farmers side	Small scale farmers (%)	Large scale farmers (%)	Average losses (%)
losses during harvesting	5.5	4.5	5.0
losses during packaging	6.3	5.7	6.0
Average losses (%)			11.0

Source: Field Survey, 2019.

2.4.2 Supplier's profile

Volume of the collection by suppliers at one time

Distribution of suppliers according to their collection of vegetable during one time

The figure signified that large-scale supplier collected above 60 crates at a time, which was relatively low compared to small-scale suppliers. The amount of collection was nearly the same by all categories of suppliers. This could also be interpreted as the supply of vegetable through small-scale suppliers, and large suppliers were approximately the same in the market.

Table No. 2.11 Collection of Vegetable at one time

Range of collection (crate)	Percentage (%)
Small scale (up to 60 crate)	70.0
Large scale (above 60 crate)	30.0
Total	100.0

Source: Field Survey, 2019.

Loss during collection

Loss during vegetable collection by suppliers was 1.5 percent; the data showed that in every 576 crates collection of tomatoes, 9 crates were wasted during the collection.

During the collection process of suppliers, the major losses were physical and mechanical. While transferring vegetables from bamboo baskets or crates of farmers to supplier's packaging materials and uploading the vegetables into the supplier's vehicle, these losses occurred.

Loss during Transportation

The result showed that the loss that occurred during transportation of vegetables from farmer's field to supplier's distribution centers was 2.7 percent in 45 km distance of transport. These were mainly physical losses that occurred due to the bumping of roads and vehicles while traveling from one place to another. Though the crates were used as packaging materials, physical and

mechanical damage occurred due to the imbalanced structure of the road and speed breakers where the carriage vehicles get bumped, which caused pressure on the vegetables.

Loss during storage by suppliers

The information showed no significant loss during the storage by suppliers. The suppliers did not have to store vegetables before supplying them to retailers. They sold vegetables as soon as they brought them to their market distribution center.

Loss of suppliers selling and selection process by retailers

The result showed a 2.4 percent loss of vegetables during the selling process by suppliers. While selling 576 crates of vegetables, 14 crates were wasted. These losses occurred on the supplier side while interacting with the retailers. The retailers handled vegetables roughly while selecting and removing unhealthy vegetables during their purchase. In multiple interactions of vegetables with the retailer's selection process, the initially good vegetables also get destroyed. The study found that small-scale suppliers have relatively high losses than large-scale suppliers, but in the case of supply to retailers, level losses on large-scale suppliers seem much more.

Table No. 2.12 Loss in supplier's side

Range of collection	Losses during collection	Losses during transportation	losses during supply to retailers	Total
Small- scale (1-60)	1.6	3	2.3	
Large -scale (above 60)	1.4	2.8	2.5	
Average losses	1.5	2.7	2.4	6.6

Source: Field Survey, 2019.

2.4.3 Retailers Profile

Retailer's behavior of purchasing.

From the information, 75 percent of retailers were small scale retailers who offered to purchase up to three crate vegetables at a time. Large scale retailers purchased more than three crates at a

time. The purchasing behavior of retailers was related to their capacity of selling to the customers. Most of the retailers could sell up to two crates⁴⁴ at a time.

Table No. 2.13 Retailer's behavior of purchasing vegetables

Range of collection	Bamboo Basket	Plastic bag	Crate	Total %
Small- scale (up to three Crate)	17.25	32.23	25.52	75.0
Large -scale (more than three Crate)	8.19	3.21	13.71	25.0
Total (%)	25.19	35.44	39.23	100.0

Source: Field Survey, 2019.

Distribution of retailers during collection

The losses of retailers during the collection of vegetables from the suppliers was 2.3 percent during the collection of 22 crates of vegetables, 0.506 crates of vegetables were wasted, as shown in the table below.

The losses occur when the retailers' purchased vegetables in a crate or two. As 75 percent of retailers purchased vegetables in less than or equal to a crate, they could only select vegetables and pick up the good ones. In this process, losses to retailers were significantly less. When the retailers purchased a crate, they could not select and pick up the good ones. In this case, they had to take some probably wasted vegetables inside the crate, which incurred a loss of 2.3 percent on the retailer's side.

Losses of vegetables while transporting from supplier POS to retailers POS

The losses of vegetables while transporting from the supplier's distribution point to the retailers selling point varied with the transportation model. The result showed that the retailers had used bicycles, motorcycles, DI vans, and self-carrying modes of transport to carry vegetables from the supplier's distribution point.

⁴⁴One Crate equal to around 20 kg

Distributions of retailers according to their use of packaging material during transportation.

The result showed that 40 percent of retailers used the crate as packaging material, and 60 percent used polythene while transporting vegetables from suppliers. The retailers who carried vegetables on a bicycle or public vehicle used polythene bags for their convenience. Others who purchased vegetables, a crate or two, had used motorcycles and other vehicles of their convenience for carrying the vegetable from suppliers.

Table No. 2.14 Distribution of retailers according to the packaging material used

packaging material	No of retailers	Percentage
Polythene bag	12	60.0
Crete	8	40.0
Total	20	100.0

Source: Field Survey, 2019.

Total loss occurred until a vegetable reaches to retailers POS

The result showed that the loss of vegetables during the transportation of vegetables from suppliers to the retailer's selling point was 1.8 percent; while transporting 22 crates, there was a loss of 0.40 crates.

The losses that occurred during the transportation from retailers to the suppliers were physical and mechanical. While transporting, there was damage to vegetables due to vehicles' bumping, striking vegetables during the loading and unloading process, and pressure while carrying in polythene by self.

Loss in vegetable during storage by retailers

The result showed that retailers' loss of vegetables during storage was 1 percent. There was a loss of 0.22 crates while storing 22 crates of vegetables.

The retailers have to store their unsold vegetables in their ordinary rooms for two days. They have no proper storage facilities. As vegetables are easily exposed to decaying, the unsold items get damaged if retailers have to store them for a day or more than one day.

Loss during retailing

The loss of vegetables during retailing was found at 3.6 percent. This was a significant loss on the retailer's side. The data showed that while selling 22 crates of vegetables, 1.92 crates of vegetables was wasted.

Table No. 2.15 Loss in Retailer's side

Types of losses in retailers' side	Total collection (Crate)	Total losses (crate)	Losses (%)
Losses during collection		0.51	2.3
Losses during storage by retailers		0.22	1
Loss during retailing		0.79	3.6
Losses during transportation	22	0.39	1.8
Total	22	1.91	8.7

Source: Field Survey, 2019.

2.4.4 Summery Chart

The study showed that overall losses of vegetables in the supply chain from field harvesting to retailing were found at 26.3 percent. Among these, 5 percent of losses occurred during the harvesting process by farmers in the field. 6 percent of losses occurred during the packaging process by farmers. 1.5 percent of losses occurred during collection by suppliers. 2.7 percent of losses occurred during the transportation process by suppliers. 2.4 percent of losses occurred during the supplier's POS. 2.3 percent of losses occurred during collection by retailers. 1.8 percent of losses occurred during transportation by retailers. 1 percent of losses occurred during storage by retailers. 3.6 percent of losses occurred during retailing. The majority of losses, 6% of vegetables in the supply chain, were found during the farmer's packaging process.

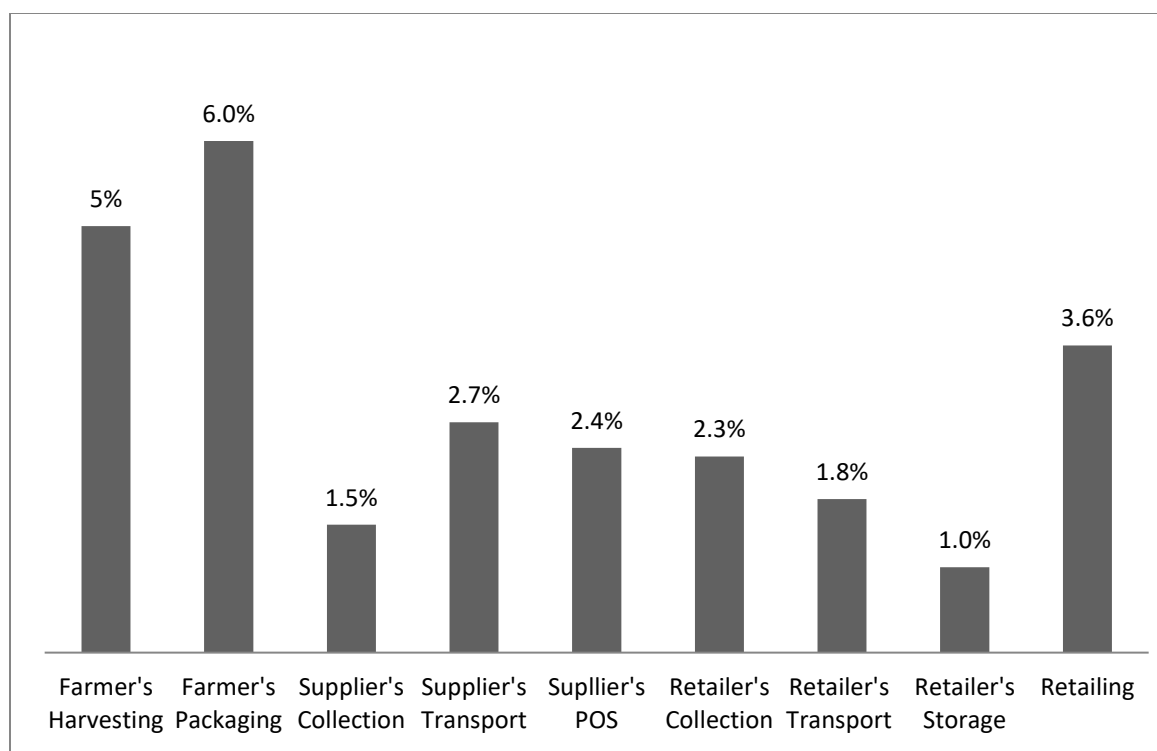


Figure: 2.5 Postharvest Loss of Vegetables during the supply chain system, Source: Field Survey, 2019

The survey found that the postharvest losses of vegetables in the entire cycle is 23.6 percent which means a massive number of vegetables goes to waste, which can be reduced by changing techniques and technology that can help to improve farmers, wholesalers, and retailers' economic status. Due to a lack of accurate data from the farmers, it has not been possible to estimate the damage caused by wild animals. If those figures are available, the rate of loss on the part of the farmers will increase. Other research from many developing countries and even in Nepal has mentioned that losses on the retailer's side are higher than on the farmers' and wholesalers' sides, but this study denies that. The farmer's side losses are higher than other sides.

2.5 Summery and Conclusion

Vegetables are the essential crops widely grown all over Nepal. The study was conducted in different districts of Nepal. The primary data were collected from the field survey. In contrast, secondary data were collected by reviewing various published and non-published documents, reports, research papers, books, booklets, and information related to the study.

A total of 60 samples were taken for the study, of which 30 were farmers, 10 were suppliers, and 20 were retailers. The sampling method followed was Random sampling of research methodologies. The data collected from the field was digitized into MS Excel, and further analysis was done using various features of MS Excel. The data units were standardized into a single unit for uniformity of results and analysis. In this study, the quantity of vegetables was measured in Crate, and the area of land was measured in ropani later it was converted to hectare (ha). The analyzed data were presented in tables and charts.

Three sets of questionnaires were developed incorporating Farmers, Suppliers, and Retailers to identify postharvest losses during the supply chain of vegetables. A field survey was conducted through face-to-face interviews using a semi-structured questionnaire for each player in the supply chain system. Besides this, the general information about the respondents, like age, educational attainment, main occupation, annual income, government subsidy, losses by strike etc., was also included in the socio-economic condition of the respondents. The age of respondents was classified into four categories (20-30, 31-40, 41-50, and above 50 years). The farmers belonging to the age group of 41-50 were relatively more engaged in vegetable production. Among the farmer respondents, it was found that 53 percent of females and 47 percent of males were active in vegetable production. The literacy level of the respondents was found that 43.3 percent were educated till primary level, 23.3 percent were illiterate, 26.7 percent achieved secondary level education, and 6.7 percent achieved high school certification.

Production areas of vegetables, out of 30 farmers, 76 percent were small-scale producers, and 24 percent were larger-scale vegetable producers producing. The result showed that 88.60 percent small scale producers and 11.40 percent were large-scale producers. About 46 percent of farmers generated up to NRs 50,000 per year, whereas 7 percent had generated an income above NRs 150,000 per year.

On the farmer side, the total loss during harvesting and packaging was 11.0 percent in the supply chain of vegetables. In field harvesting, the loss was 5.0 percent, and in the packaging process, the loss obtained was 6.0 percent. Many reasons are involved for post-harvest losses, but the primary factors are lack of education of farmers on harvesting methods, knowledge about products, packaging skills and materials, lack of crop processing, etc.

The losses on the supplier's side were calculated through the collection process, transportation, and distribution to retailers. The total losses of vegetables on the supplier side were 6.6 percent in the supply chain of vegetables. During collection, the suppliers had a loss of 1.5 percent; during transportation, the loss was 2.7 percent, and during distribution, the loss was 2.4 percent.

It is estimated that in the supply chain in the United States, 18 percent occurs in the phases of retail and distribution.⁴⁵ But in the case Nepal total loss of vegetables in the supply chain was 8.7 percent on the retailer's side. Farmers' activities, such as packaging, sorting, selection, etc., also cause supplier losses. If the farmer packages properly, the loss during transportation will be less.

The losses on the retailer's side were calculated through four dimensions (Collection, Transportation, Storage, and Retailing). During collection, retailers had a loss of 2.3 percent, during transportation loss was 1.8 percent, during storage loss was 1 percent, and during retailing or selling loss was occurred 3.6 percent.

The overall losses of vegetables in the supply chain from field harvesting to retailing were found at 26.3 percent. The major losses of vegetables in the supply chain were found during the farmer's packaging process. This loss was incurred on the farmer's side as suppliers used to pay farmers the total amount of money by deducting the amount of two kg per crate. This signified that the farmers had to go through a two kg direct loss.

Present investigations conclude that the overall losses of vegetables in the supply chain from field harvesting to retailing were 26.3 percent. Among 26.3 percent, the total losses on the farmer's side were 11.0 percent, whereas the loss that occurred during harvesting was 5.0 percent. Their second loss occurred during packaging, a significant loss of 6.0 percent on the farmer's side. The survey shows that the high level of losses occurs from the farmer's side; this is a lack of proper education about harvesting techniques, material, etc. In the case of the farmer's side, my survey data also match with the GC Arun.⁴⁶ But the case of the India postharvest losses of vegetable from the farmer's side up to 15 percent.⁴⁷ According to the survey, Indian farmers are also suffering from postharvest loss problems; the reason is that Indian farmers are also not well

⁴⁵Astill (2020).

⁴⁶GC(2019). P. 127.

⁴⁷Hegazy(2013). p.7.

educated about vegetable farming. They are also accepting traditional methods as a sort of Nepal. The suppliers undergo some losses in the supply chain system of vegetables. The suppliers reached to farmer's field and collected the vegetables in crates. During the collection, transportation, and distribution process, the suppliers had losses of 6.6 percent of total purchased vegetables from the farmers. Where 1.4 percent losses during collection, 2.7 percent losses during transportation, and 2.4 percent losses during suppliers POS was occurred at suppliers' side. The retailers had major losses in the supply chain system of vegetables. Their major activities included in the supply chain of vegetables were a collection from suppliers, transportation, storage, and selling. During those activities, the retailers had losses of 8.7 percent of total purchased vegetables. Where 2.3 percent of losses occurred during collection, 1.8 percent of losses occurred during transportation, 1.0 percent of losses occurred during storage, and 3.6 percent of losses occurred during retailing at the retailer's side. Retailers are used to their losses; they are not aware of reducing losses by accepting new methods and technology.

The main reasons for postharvest losses in Nepal are lack of product knowledge, infrastructure, storage facilities, poor market means (supply channels), traditional harvesting methods, production methods, the timing of harvesting, technology, transportation system, packaging, and storage technology, etc., the survey revealed. Geographical conditions, global warming (climate change), road facilities for transportation, lack of markets, government policies (tariffs on incoming vegetables), etc., are reasons for postharvest losses. It can reduce y losses by providing adequate training and awareness programs to farmers, traders, and retailers related to vegetable production. Farmers should especially pay attention during the harvesting, guarding, sorting, and packaging.

The government should provide an environment to go insurance in the agriculture sector so the financial losses could be reduced on the farmer, wholesaler, and retailer's side. The government of Nepal should support small-scale producers to combine as producer groups for large-scale production and standardize the commercialization process so that they could get most of the benefits from their production and investment which sill also helps to reduce postharvest losses. Insurance facilities and training about product and production technology help reduce postharvest losses of vegetables as well it will also motivate newcomers in the farming sector.

Because of the diversity of the geographical condition of the nation, postharvest losses may be different in different places. In the survey area, I found the respondents are not aware of the postharvest losses of vegetables. If they can give enough attention to the control of postharvest losses of the products, there is a chance to reduce 20-30 percent of their present losses.

This study has identified the losses in various sectors of the supply chain, which will facilitate farmers, wholesalers, retailers or policymakers, and relevant government agencies to solve the problem. The loss ratio of a developed country like Nepal and Japan is quite different; education, government subsidy, government policy, harvesting equipment, storage facilities, transport vehicle, road condition, and market channels are the significant factors causing loss differences.

Finally, the study concludes farmer activities such as harvesting method and time, harvesting skill, packaging method, and material are affecting losses on their side as well as losses on the wholesaler and retailer's side in transportation and storage are affected by farmer's activities. So, farmers need to pay attention to their activities to control postharvest losses.

Chapter 3 Postharvest practice and food losses in Japan (42-97)

3.1 Introduction

Background of the study

In recent years, there has been a growing awareness of issues related to postharvest losses. Despite providing food to 7.6 billion people worldwide, 821 million people suffer from starvation. On the other hand, global food losses and food waste are about 1.3 billion tons annually. This means that about one-third of the 4 billion tons of food produced for human consumption is being wasted. Reducing food waste is not as difficult as producing it, so it is possible to save significant amounts of food by reducing postharvest losses and food waste, which can be provided in needy places.

The postharvest losses ratio of Japan is meager but responsible for about 6.5 million tons of food loss annually. This means losses after reaching the plate are high in Japan. The annual amount of food aid implemented globally by the United Nations World Food Program (WFP) is about 3.8

million tons,⁴⁸ which means that Japan alone is spending almost twice as much as the WFP. Simultaneously, the world's population is growing and is expected to reach 9.5 billion by 2050.⁴⁹ Constant food loss can increase the amount of the starving. Therefore, it is necessary to find a suitable solution for food loss. When food is thrown away, land, water, labor, and materials used for production are all wasted. The greenhouse gases generated from this treatment contribute to natural disasters such as droughts, which create a vicious cycle that damages agriculture. Economic losses due to food waste (excluding fish and shellfish) are estimated at US \$ 750 billion (approximately 82 trillion yen). This is Japan's national estimate of 101 trillion yen in the fiscal year 2019 is more than that amount. Thus, food loss and food waste adversely affect the environment and economy of the country.

Japan is an island country with diversified geographical territories and a deep agricultural history. Postharvest losses mainly include the top of the supply chain in developed countries and waste at the top of the supply chain in less developed countries. The same situation applies in the case of Japan as well. Most of the losses are due to a lack of knowledge, technology, and fund for agriculture in developing countries. Most of the losses are due to the trade practices (Subsistence farming) of developed countries and consumer behavior, values, and economic considerations.

The diverse agro-climatic conditions prevailing in Japan are conducive to cultivating fruits and vegetables at different stages of the year. Vegetables are always at risk of damage during and after harvest. In the midst of the food crisis, it is imperative to address the root causes of these problems. Addressing these problems can make a significant contribution to combating food insecurity in developed and developing countries and improving the livelihood of those engaged in the agriculture and farming sector.

According to research, about one-third of the world's food is lost or wasted before it reaches its final consumption. As natural resources dwindle and agricultural productivity becomes saturated, there is a growing global interest and much needed to reduce these deficits. This study (postharvest practice and food losses in Japan) was conducted in three different provinces of

⁴⁸World Food Programme (2017). P. 4.

⁴⁹The Food and Agriculture Organization (2009). pp. 2-4.

Japan (Tokyo, Kanagawa, and Saitama). This study represents the majority of farmers in Japan and helps to find out the thematic status of Japan's agricultural sector. Primary and secondary data were taken to complete the study. 48 interviews were conducted, out of which 25 were farmers, 5 were vegetable shops, 10 were supermarkets, and 8 were vegetable distributors (suppliers). Developing countries has extremely high postharvest losses, ranging from 20% to 50% of production, and reducing them may be the fastest way to improve the food supply chain.⁵⁰We are all aware about the thing that increasing the production is very tough task than reducing postharvest losses rate. What we need to understand here is that it is important to first identify the factors that cause postharvest losses. There is no accurate formula that can quickly control postharvest losses in a certain period of time but the important part is that it is influenced by several direct and indirect factors. First of all, those factors should be identified and that it is possible to address suitable solutions.

This study is mainly focusing on small scale farmers income generation, education level of the farmers, problem facing during and after harvesting, market structure, Japanese government engagement in farming sector, postharvest losses ratio in farmer, suppliers and retailer level, Japanese consumer behavior, harvesting tools and technology, marketing channel system market competition, food losses in Japan, etc.

With the development of various technologies, the convenience of living has improved, and we are now living comfortably. Today we do not hesitate to attack the rights of others for our convenience. For example, let's look at our daily behavior; how many others have been affected by our daily activities? The food crisis is on the rise globally, and we need to pay attention to it as soon as possible. On the one hand, the food crisis is on the rise, and the other hand, the food losses are also at the same rate. With all this in mind, reducing postharvest losses is urgent today. However, in 2016, the food losses in Japan were about 6.4 million tons, which is declining compared to the previous year. Also, looking at vegetables alone, about 1.92 million tons of vegetables harvested in 2017 could not be delivered to the market.⁵¹

⁵⁰Hodges, et al. (2011). pp. 37-45.

⁵¹Ministry of the Environment (2019). P.1.

Many researchers said that postharvest losses are up to 50 percent in developed and developing countries. But so far, the main reason has not been identified. Postharvest losses are not just for one reason, but many small things are involved. This study helps solve the problems by revealing the critical factors of postharvest losses.

Japan is known for a country that is self-dependent on fresh vegetables but the recent year dependency rate is increasing. According to the data of 2016, about 13.4 million Metric tons of vegetables were produced, of which potato was the highest at 16.4% and cauliflower at 10.8%, Japanese radish 10.2% and Japanese onion 9.3 % and so on. Japan imports 5 to 6% of its fresh vegetables each year, China is the largest exporter of fresh vegetables in Japan. Second and third place taken are New Zealand and the United States.⁵²

More than 150 types of vegetables are eaten in Japan. Vegetables are often divided into three main categories, leafy vegetables, fruit vegetables, and root vegetables, depending on the portion used. Green vegetables include spinach, Japanese zucchini spinach, salad, cabbage, and Chinese cabbage. Fruits and vegetables include those who eat immature fruits like cucumber, eggplant, and chilly and those who eat ripe fruits like tomatoes and melons. Root vegetables include radishes, carrots, birch root, lotus roots, etc. Some kinds of vegetables available in the Japanese markets are rare and not eaten in other countries, which include water dropwort, Japanese hornwort, wasabi, Japanese butterbur, rakkyo, asatsuki, gold band lily, mioga ginger, and Japanese pepper, etc. It is not uncommon for dishes and types of food to differ according to culture, but in the case of Japan, Japanese food is famous worldwide. The way Japanese people cook and eat vegetables is also very different from other countries. Therefore, Japanese farmers' farming methods and technology are also slightly different from other countries and regions.

Considering the relationship between the time used as a vegetable and the plant's growth stage, freshly germinated roots (moyasi), young leaves, mature leaves, flower buds, immature fruits, ripe fruits, etc., are used as vegetables for food in Japan. In other words, the growth stages used as vegetables are very diverse and wide from birth to death. For example, tomatoes can be

⁵²Motomura (2018). pp. 3-7.

chosen for different dishes depending on the rippling stages and color since the country's food culture influences the optimal harvest time. In Japan, seeds are used exclusively in commercial farming to improve the growth of many vegetables, such as pest resistance, harvest time, and size. On the other hand, in recent years, interest in various native species has increased in rural areas.

According to a questionnaire survey on the purchase of agricultural products, freshness is the most important factor when consumers buy vegetables. Still, the current situation is such that the freshness of vegetables has yet to be defined and evaluated easily. In the supermarket, this is often assessed subjectively by appearance. When considering the quality of vegetables, there are conditions other than surface freshness. The outer shell of the vegetable does not reflect the internal quality and physiology, which is the problem. I want to pay attention to the crop as the starting point for the decline in freshness. "Harvesting" is an artificial surgery that will make a big difference in the physiology of vegetables. The climate, harvesting time, and season directly affect the freshness of vegetables. Therefore, vegetables should be harvested very carefully. Some vegetables need to be soaked in as soon as they are picked, while others need to be dried in the sun. The method of cutting and picking varies depending on the species of vegetables. Those activities are directly related to postharvest losses.

The quality of vegetables could be more stable depending on the variety and farming conditions, and the quality deteriorates rapidly after harvesting. Hence, various problems in food distribution still need to be solved. To solve this problem, it is necessary to clarify the mechanism of quality change from a freshness perspective and develop quality control techniques based on postharvest physiology. In recent years, an environment has been established where metabolism analysis, which investigates the changes in the metabolic system as a whole at the level of matter, and transcription analysis, which extensively examines gene expression, can be applied to vegetables. The current problems will be solved as much as possible with new efforts in the coming days by learning lessons from the ancient farming system and its concerns.

Since the 1990s, demand for home-grown vegetables has declined, and demand in the processing business has grown by more than 50%.⁵³ It has also had a direct impact on the Japanese market.

⁵³Motomura (2019). pp. 1-8.

Today we can easily buy frozen vegetables in the market. We can buy our favorite vegetables in any season, which is one of the essential characteristics of frozen vegetables. Processing vegetable raw materials require four characteristics: fixed time, fixed quantity, fixed price, and fixed quality. When viewed as industrial raw materials, these are natural requirements, considering the characteristics of vegetables whose quality depends on variety and farming conditions and take work to fulfill. It will be essential to strengthen the production of vegetables, including raw materials for processing, and to store and supply vegetables at affordable prices while minimizing quality changes in the future. Processing vegetable helps to reduce postharvest losses because it reduces wastage during transportation, losses because of lack of market, etc.

3.1.2 Purpose and structure of the study

The purpose of this study is to analyze the causes of postharvest losses and food losses, take measures to improve them, and reduce the gap between information and data on postharvest loss measurement, pattern, and causes. The study provides reliable statistics on postharvest losses at the Japanese smallholder level and identifies targeted mitigation strategies at the policy and technical levels. It helps various stakeholders to participate in food loss reduction programs and realize the benefits of improved postharvest handling practices. Also, the study is expected to be helpful in Nepali farmers in reducing postharvest losses by providing technology Japanese farmers' practice. The specific objectives of the survey are as follows:

- 1) To evaluate and understand the Japanese vegetable market
- 2) To comprehend and understand the Japanese supply chain system and whether it is possible to apply it in Nepal
- 3) To understand the government's involvement in the farming sector
- 4) To find out how much postharvest losses account for Japan's food losses

5) To know what advanced types of agricultural equipment are used at the farmer, wholesale and retail levels?

6) To find out where the postharvest rate is higher and why

The following questions were asked to farmers to achieve the purpose of the study.

1) What are the current structures of the postharvest practice in the study area?

2) What is the magnitude and causes of food losses in different segments of the supply chain?

3) Where are the biggest losses in postharvest practice? What are the potential improvements that can be implemented to increase postharvest processing efficiency along with the value chain?

3.2 Literature review

3.2.1 Overview of postharvest losses and related factors

Problematic climatic conditions, managerial and technical limitations in infrastructure, packaging and marketing systems, harvesting techniques, and storage and cooling facilities are the reasons for postharvest losses in developing countries.⁵⁴ Technology transfer from developed countries to developing countries may be feasible to reduce postharvest losses. Innovative ideas and prototypes bring them to the community to enhance postharvest activities and reduce losses; advanced technologies should be introduced at the farmer level. Develop and promote a package of exercises based on the area-specific requirements and identify challenges after training to enhance the skills and knowledge of farmers in postharvest management.

Japan has developed the technology over the past two decades from rapid harvesting to consumption with careful cutting and sorting, strict standardization, development of suitable packing materials, mechanized pre-cooling facilities, refrigeration systems, and hygienic performance.⁵⁵ From a technical point of view, three significant changes have occurred during the modernization of traditional systems. First, the chemistry of agriculture is increasing, and then

⁵⁴Food and Agriculture Organization (2011).

⁵⁵Saijo (1989). pp. 1-13

there is a slight decrease. Second, there has been the increasing mechanization of agriculture. Spade cultivation has been almost entirely replaced by tractor-driven, rotary cultivation. Third, the use of hybrid seeds is increasing.⁵⁶ The harvesting method is an essential factor in farming; in Sri Lanka, 30-40 percent of foods and vegetables are lost every year due to poor harvesting methods and techniques.⁵⁷ The study of Saijo (1989) shows that more than 50 years ago, Japan developed postharvest technology to help reduce postharvest losses. Recently Japan has modernized those more practical techniques to control the deficit. If those techniques can be introduced in developing countries like Nepal, postharvest losses can be reduced. Postharvest research, education, and extension are very inactive in Nepal. Improving the harvesting area is essential for stabilizing the food supply in Nepal. There is an urgent need to enhance agricultural and rural development by promoting agricultural research and technology transfer and strengthening inter-sectoral cooperation.

Postharvest losses in the food sectors of individual economies in the Asia-Pacific region are influenced by various critical economic, technological, and trade-related factors. These include harvesting, packaging, handling, transportation, storage, and marketing along the supply chain of each specific food sector, etc.⁵⁸ This study explains the reasons for postharvest and food losses very well, but this paper needs to focus on the potential impact of adopting specific measures to reduce food losses. It also does not explicitly consider environmental factors such as temperature, oxidative stress, and water activity. The effects of postharvest environment manipulation by ethylene, natural edible coatings, and controlled environment storage on fungal viability are also not negligible.

In Japan, Seven & I is a conglomerate organization, with food accounting for about 60% of total sales, which in its manifesto refers to food loss, waste, and waste recycling as one of the themes of the "Green Challenge 2050". The organization aims to reduce food loss and destruction by 50% by 2030 and 100% by 2050 compared to 2013.⁵⁹ If Nepal also establishes such an organization with the aim of reducing postharvest losses, it will help in reducing the losses to a great extent.

⁵⁶Backhurst (1985).

⁵⁷Rajapaksha, et al. (2021).

⁵⁸Gunasekera, et al. (2017).

⁵⁹Seven & i Group's (2019).

The postharvest losses of vegetables in Japan are approximately 8-15 %.⁶⁰ While the postharvest loss rate in developing countries is around 20-50%, in the case of Japan, the postharvest loss of vegetables is only about 8-15%. This result makes it easy to understand how techniques and methods can reduce losses. Generally, about 30% of fruits and vegetables in Nigeria become unfit for consumption due to spoilage after harvest.

Due to the postharvest losses, a massive amount of money goes to waste every year, although less than 5% of funding for agricultural research is allocated to postharvest systems.⁶¹ The lengthy chain of marketing systems of vegetables between farmers and consumers makes it difficult to access.⁶²

Japan has a powerful marketing channel where JA group covers almost vegetable trade in Japan. Food distribution in Japan takes place when agricultural products are harvested. Farmers store it in the local warehouse of the Japan Agricultural Cooperative (JA). JA has many connections with various wholesale markets throughout Japan. Wholesalers receive produce from warehouses and bring it to these markets.⁶³ But the vegetable supply system in Nepal faces various limitations and risks at different levels. Such as transportation difficulties due to geographical disadvantages, lack of storage facilities, unnecessary intermediaries, lack of market facilities, suitable vehicles, etc. Due to the deadlock distribution system, Nepalese farmers cannot sell their produce smoothly, which is also the primary reason for the postharvest loss in Nepal.

Traders and organizations play a crucial role in creating an organized marketing channel. The urban marketing system in Ghana is heavily influenced by trade organizations that contain traders and have authority over price negotiation, dispute resolution, and supply control.⁶⁴ Rural area farmers of Nepal cannot sell their products because of the transportation problem. They are not getting a reasonable price for their product even if they can sell. The channel between farmers and sellers could be better in Nepal; a lack of connection with traders is one of the biggest problems for farmers in rural areas. Farmers can get financial benefits and reduce losses

⁶⁰Kitinoja, et al. (2015).

⁶¹Kader (2003).

⁶²SM, et al. (2019).

⁶³Motomura, C. (2018).

⁶⁴Lyon (2000)

if they can link with traders; otherwise, they can be unified (group, club, etc.) and sell their products by themselves.

In Japan, food waste decreased from the 1960s to the mid-1970s, increased from the mid-1970s to the late 1990s, and declined after 2001.⁶⁵ Food waste in farmers, wholesalers, and retailers is shallow, but in developing countries like Japan, food losses at the consumer level are very high.⁶⁶

Moisture loss, scratching and subsequent decay are the major degradation types responsible for the disposal of fresh fruits and vegetables. Several factors (processing, storage and transportation conditions) play a role in these adverse reactions during the journey from producer to consumer of vegetables.⁶⁷

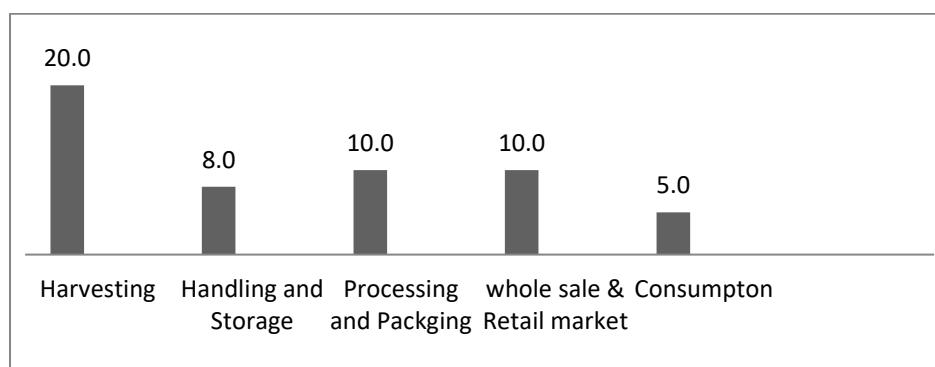


Figure: 3.1 Diagram of fresh fruit and vegetable supply chain illustrating the waste generated at each stage of Turkey, Source: Elik, et al. (2019).

The problems of postharvest losses in Turkey are almost the same as those of Nepal, so there are many possibilities for different general strategies to control food loss. Strategies to reduce postharvest food losses include: improving existing garden management systems (particularly package and cold chain maintenance), using existing knowledge to ensure their quality and safety, and overcoming socio-economic constraints like inadequate infrastructure, poor marketing strategy, weak research and development capability and promoting vertical consolidation integration among horticultural crops and growers. Lack of infrastructure and inadequate cultivation techniques in many developing countries are likely to remain significant

⁶⁵Liu, et al. (2016).

⁶⁶Food and Agriculture Organization (1994).

⁶⁷Elik, et al. (2019).

factors in food waste generation. In the Philippines, 30–50% of food is wasted annually due to poor infrastructure.⁶⁸

China is the largest vegetable-producing country, with 9,600,000 hectares of vegetable production. Every year there is a massive economic loss due to poor crop facilities.⁶⁹ The Chinese government has already recognized that more attention should be paid to increasing grain production and promoting postharvest technology, improving quality, and reducing postharvest losses. There are 67 agricultural universities and 210 agricultural schools, which have trained many agricultural experts in China. The Chinese government attaches great importance to technical and literacy education. In Nepal, there is immensely few such institutions and effective training centers. We can improve our farmer's education level in agriculture by providing such training and organizing internship programs, which will be the backbone for reducing postharvest losses.

The effects of climate change have created another challenge for farmers in developing countries to protect their crops.⁷⁰ Recent climate change is becoming a significant factor in postharvest losses of crops; in India, global warming and climate change have affected vegetable cultivation and postharvest losses.⁷¹ Nepal is also not an exception; the 2008/9 winter drought in Nepal was one of the worst, with less than 50% rainfall, significantly affecting crop production across Nepal. Hill and mountain agriculture were more affected than lowland (FAO, 2009). It is suitable for growing vegetables in greenhouses with rising temperatures, as Japan is practicing. The farmers of Japan are using a temperature control system in the greenhouse; if the technology can be transferred to the Terai region of Nepal's farmers, it will significantly benefit them.

Japan has a very advanced packaging system that minimizes losses during storage, transportation and during marketing.⁷² Packing systems and materials play a significant role in postharvest losses, with most production sites in underdeveloped countries being far from the market. According to the FAO report 40-45 percent of the postharvest losses occur due to the poor

⁶⁸Mopera (2016).

⁶⁹Feng (1998).

⁷⁰Prasad, et al. (2015).

⁷¹Kumari, et al. (2018).

⁷²Kashiwagi (2114). pp. 3-22.

packaging system or materials.⁷³ Estimated that postharvest losses of Fresh Horticultural Food Crops in developing countries, from production to retail level 5–50, at retail, food service, and consumer sites 2–20, of total percentage of losses.⁷⁴ But the survey found only around one percent losses during Japan's loading, unloading, and transportation. The package of Nepal may vary to a lesser extent as compared to developing countries. The packaging is done locally by farmers at the farmer level, with the facilities they provide. Some practices are local plastics, crates, bamboo boxes, etc., and the packed material is placed in a bunch with one on the other. This can reduce the moisture content of fruits and vegetables, which leads to postharvest losses during transportation and the supply chain. It is possible to transfer packaging technology from Japan to Nepal; by improving the packaging system, it is possible to reduce postharvest losses in Nepal.

Government policy also plays a significant role in postharvest losses, with the Japanese government controlling supplies through regulations and policies, which will help maintain the market demand.⁷⁵ By controlling inputs from abroad, the need for the national vegetables will be high, so the product will not have to be thrown out of the market. Due to the lack of a market in Nepal, Nepali farmers have to throw away their produce. Nevertheless, in such a case with a large number of vegetable inputs from the Indian market, Nepali policymakers should learn from Japanese policy and make suitable policies for Nepal, such as the conservation of natural resources and protection of the environment, food, and nutritional security. Diversification of agriculture, Management of inputs for efficiency, Development of rural infrastructure, Marketing and value addition, Revitalization, etc. Opening a functional food industry to control postharvest losses of vegetables can also be a solution. Vegetables can be used as raw materials because the production is high in the season and the market demand is low so that the farmers can find a market there, and the problem of postharvest losses due to lack of market can be solved.

Japan's domestic production almost meets market demand; it Imports only 5-6% of fresh vegetables. Japan mainly imports fresh vegetables from China, New Zealand, and America.⁷⁶ In the past few years, the import of Nepali vegetables has increased rapidly, but exports have

⁷³Food and Agriculture Organization (1994).

⁷⁴Kader (2005). pp. 2169-2176.

⁷⁵Kroeksakul, P., & Srichaiwong, P. S. (2018).

⁷⁶ Motomura, C. (2018).

decreased. Imports accounted for 60% of the total vegetable trade in 2017; Most of Nepal's vegetable trade is with India.⁷⁷ Homegrown production may also result in fewer postharvest losses. If the farming sector develops rapidly, modern agricultural technology innovations will also be made.

3.2.2 History of Japanese agriculture

The agricultural community evolved about 10,000 years ago when humans began to raise plants and animals. By establishing households, families and large groups were able to build communities and rely on hunting and hunting for transition and survival from nomadic hunting lifestyles.

Japan has a deep history of agriculture and has gone through many stages to come into today's modern society. In the history of Japanese agriculture, we can find the six episodes of agriculture development: The Jomon, Yayoi, Tohoku Yayoi, Satsumon and Ainu, Okhotsk, and Gusuku come in the front line. These events include both the adaptation of indigenous peoples and their migration and spread within the Japanese archipelago. Among those episodes the Jomon is the most ambiguous with evidence of niche construction anthropogenesis that included domestication, cultivation, tree management and potentially wild-pig management. The events of Jomon's time are parallel to those of eastern North America, Papua New Guinea, and China, many researchers have shown that the prevalence and migration in post-Jomon events (Yayoi, Tohoku Yayoi, Satsumon, Okhotsk, Gusuku) are also parallel to parts of North America (including the Northwest Coast) and Europe and Oceania.

Agriculture was a relatively late and sudden development in Japan. Since the Meiji Restoration (1868), agricultural statistics have been greatly expanded and enhanced in Japan. Japanese government agricultural policies and methods of data collection are closely linked and interact with each other throughout this period. Feudal system-1868-Closed society, technologies were developed and accumulated within local government level, or even village level. 1868- The Meiji restoration. 1870-1880 government introduce of western farming technology: but this program

⁷⁷ Sharma, et al. (2017).

not succeed 1920- Government start to develop national research network to substitute farmer developed technology.⁷⁸

Japan was predominantly agricultural, but with the remarkably rapid growth of its economy after the Second World War, the country has been transformed into a heavily industrialized society. Government support has played a major role in developing and modernizing Japanese agriculture.

In case of Nepal, Nepal started modern agricultural development in the 1930s, with the idea of avoiding food shortages and generating income both in peacetime and in times of disaster. Nepal has also long history of agriculture and being the agriculture country, it has to be made extensive development in the field of agriculture but the current situation of agriculture is still crawling. There are so many factors that are alive for not to be developed Nepali agriculture.⁷⁹ Because of the failure of the government and agronomists there is still unable to find adequate solutions to the problem.

Another issue to be mentioned is the need for research on the suitability of crops, fruits and livestock in various ecological fields. As Nepal cannot adopt agriculture and agricultural models from other regions with different climatic and geographical features, it is necessary to emphasize on national research and study initiatives. The need for gradual improvement in indigenous agricultural practices should be emphasized. Protecting the product from diseases and pests is extremely important, as well as should be improved by traditional storage methods. Improving locally used technologies or conducting scientific research to identify those alternatives needs to be identified as another development challenge.

Around 1871-1873 Japan improved its policy of supporting global development and new technologies from the Western world such as railroad technology, central banking etc. At that time, the agricultural sector was being transformed into modern agriculture. Japanese farmers started intensive farming around the 17th century. The country had been affected by the expansion of agriculture, with cash crops and mono cropping, the pattern of agriculture affected the farmers by the increase in the size of the farms, deforestation etc. in the 18th century.

⁷⁸JICA(2018).

⁷⁹Dahal (1997). pp. 2-9.

Japanese agriculture introduced new systems for agricultural production, such as multiple cropping, new plant varieties, fertilizers and new agricultural tools.

Among developing countries, Japan is not unique in agricultural protection, but it is unique in the relationship between agricultural protection and agribusiness and production. Although domestic agriculture is highly secure, recently imports of Japanese agricultural products are growing rapidly and food self-sufficiency is declining.

Japanese agriculture is protected by policy instruments such as border protection, direct support for agricultural prices and subsidies for agricultural production inputs, but the main source of criticism of Japan's trade practices is the quantitative restrictions on agricultural imports. Agricultural protectionism in Japan refers to the protection of Japanese farmers and the agricultural sector from international competition and technological advances have made farming more efficient. At the state level, government agencies promote local produce and provide food safety and inspection services, soil protection and environmental protection. Government policy must balance the costs and benefits to farmers, consumers, the environment, government budgets and competing interests.⁸⁰

Agricultural promotion, market prices, assistance to farmers, duty tax, all these things depend on government policies. That is why we can say policies are the backbone of the development.

Nepali agricultural sector was in a worse situation than today so the government of Nepal introduced some policies and program to improve health of agriculture community such as *Agriculture Perspective Plan* (1994 / 95-2014 / 15): In the past, when the long-term agricultural strategic plan known as the Agriculture Perspective Plan (APP) was launched in 1994-95. APP was a comprehensive and sector interlinked plan for the 20-year period. APP has four main outcomes: Improved Governance, Higher Productivity, Profitable Commercialization, and Increased Competitiveness.⁸¹ *Agriculture Policy 2004*: The agriculture policy follows an objective of creating an enabling environment for the agriculture – led rural development. It emphasizes competitiveness of agriculture sector encouraging farmers to go for commercial

⁸⁰Adachi (2015). pp. 2-9.

⁸¹Ministry of Agricultural Development, link available at <http://www.dls.gov.np/uploads/files/ADS%20Final.pdf>

production. The policy divides farmers into two groups, small and big ones and aims to provide more resources to the small farmers.⁸²

Nepali policy makers should learn from Japanese policy and make appropriate policy for the Nepal such as conservation of natural resources and protection of environment, food and nutrition security, diversification of the agriculture, management of inputs for efficiency, development of rural infrastructure, marketing and value addition, revitalization etc.

3.2.3 Farmer aging problem in agriculture sector

The number of Japanese farmers in 2000 was 2.4 million but in 2020 this number has dropped to 1.36 million. 69% of them are above 65 years of age.⁸³ If we observe the situation, the future of Japanese agriculture could be in jeopardy. This is the time for Japanese policy makers to formulate policies to attract youth to the agricultural sector. It is better to formulate a policy on how to become self-sufficient in agricultural products.

Aging populations are emerging as challenging in many developed countries. But in the case of the Japanese, the agricultural sector is almost entirely dependent on the aging population group and this is becoming a major challenge to Japan for agriculture. The farmer's aging problem as well as Japanese youth is not willing to take up agriculture profession. This can reduce the rate of food self-sufficiency, and increased dependence on agricultural production. Thus, these factors can tip the socio-economic balance of a struggling economy. The exodus of young people from the rural areas of Hokkaido to the cities has been found to be a major cause of labor shortage. In Sapporo city, 76 percent of adolescents have already chosen a career path and wanted to enter the science and technology field.⁸⁴ This trend can increase competition and saturation in the science and technology field and many vacant slots are in others related to agriculture farming. This behavior is likely to increase the unemployment rate, despite the number of job vacancies.

⁸²MOAD (2019).

⁸³See, MAFF. "Survey on Employment in New Agriculture of 2020" (Minister for Agriculture, Fisheries and Forestry).

⁸⁴Usman, et al. (2021). pp. 3-7.

In developed countries like Japan, youth are attracted to the IT sector. But in the case of the less developed countries like Nepal, Pakistan, Bangladesh young people have fled abroad in search of employment. Whether developed or underdeveloped, the majority of the agricultural sector is covered by aged population groups due to this trend. A rapidly aging agricultural society will not only reduce food self-sufficiency, but also reduce domestic agricultural businesses, resulting in reduced income recovery.

Farming groups of the aging population are not the only problem for the agricultural future. It directly impacts the present farming system like cost, postharvest losses which are becoming a major problem in the agriculture sector. Aging farmers are continuing their traditional method and equipment for farming. In such a situation the younger generation despises the agricultural profession as they see their father's hard work in agriculture and the economic situation has not improved due to that profession.

Aging farming groups and postharvest losses are interrelated. Postharvest losses have occurred due to the lack of proper handling system, selected seed, irrigation system, transportation, storage, harvesting time, market channel and climate change, etc. Aged farmers are not much aware about such things and do not even give attention to solve the problem. It is very necessary to attract the younger generation in the agricultural sector. If the younger generation is attracted to the agricultural sector, they will invent new methods and technologies which will reduce the cost and increase the benefits in the agricultural sector. This may help to draw some conclusions about the agricultural sector and make some recommendations to influence young career choices.

Agricultural education of the younger generation at high school and college level is essential. Raising the level of achievement is important and should focus on the use of crop strategies when teaching students at the university level. Those who want to incorporate agriculture as a profession needs to receive primary education from the school level where more benefits can be taken from the agricultural profession. By providing education on food loss at school or university level, it is possible to encourage students to invent modern tools for agriculture which can reduce postharvest losses.

Nepal is an agricultural country but there is not even a single chapter in the academic textbooks up to higher secondary level about the agriculture and farming education. It should modernize the agricultural sector by providing education up to the farmer level by the government and the economic support of the country can be provided from the agricultural sector.

3.2.4 Food industry in Japan

In Japan, the health and wellness trend of food and beverages has become more popular in recent years, with consumers searching for less common sources of regular products and natural alternatives. The term 'functional food' was first coined in Japan to refer to foods that claim to provide more health benefits than the nutritional value of normal foods. Japan is the world's largest functional food market, collectively owned by the European Union and North American and many healthy food industries.

It is possible to control food losses by expanding Japanese functional food to the abroad like, United States, China, Taiwan, and other developed countries. But in less developed and developing countries, such as Nepal, Pakistan, Brazil, and African countries, the potential for Japanese functional food market is very bright. There is a great opportunity to take economic advantage from the market of rural country, for this, the Japanese company must understand the demands and analysis of supply chain, regulatory structure, cultural issues, religious issues, etc.⁸⁵

The Government of Nepal and related agencies should conduct research on the potential of functional food industries. It is possible to attract Japanese functional food companies in Nepal; the government should provide a comfortable environment and security guarantee. The related agencies should be able to convince Japanese company that, Nepal is the best place to expand the Japanese functional food industry due to low labor cost, cheap ingredients and large market. India has no border barriers so the product can supply India and China.

Developing countries can also take advantage of the functional food sector to expand producer options and promote growth in the region in partnership with research centers, private entrepreneurs and indigenous communities.⁸⁶ Nepal's society is changing day by day due to the

⁸⁵Iwatani, et al. (2019). pp. 94-99.

⁸⁶Williams, et al. (2006). pp. 2-5.

influence of the society of other developed countries. In a situation where consumer behavior and demand has also changed, a functional food sector could be a golden opportunity to build a strength economy of the Nation. If we are able to develop a functional food industry, it is good for the development of the agricultural sector, as it helps to provide a market for agricultural products, agro products can be used as raw material and it helps in reducing food deficit.

The new corona virus epidemic, which began in 2020, has crippled the world economy and is restricting travel between countries. As a result, it is pointed out that there is a risk of further food shortages in specially developing countries, where many people are basically living in under the poverty line. One reason is that economic instability is hampering stable food supplies. The damage is particularly severe in countries that do not produce enough food and are dependent on imports and support. On the other hand, the problem of food loss in the world is obvious because of the lockdown in the urban areas of developed countries has forced to throw away the food that has been sold in restaurants and school lunches. In Japan, retail stores handling food and daily necessities, such as supermarket are continued to operate, but some department stores closed due to emergencies. As a result, grocery items sold in department stores has lost their place to sales due to this a massive food loss occurred. In response to this problem, attempts to buy groceries in restaurants and department stores and to sell them on the Internet became a hot topic.

More than 800 million people worldwide suffer from chronic malnutrition due to food shortages. On the other hand, the world's food waste amounts is about 1.3 billion tons per year, and about one-third of all food produced is disposed. What is the reason of the food shortage? There are many causes, but one reason is that natural disasters such as tsunamis, floods and droughts are having a negative impact. In disaster-prone areas, crops are damaged and the fields are also unable to yield, making it difficult to obtain and supply food in a stable manner. Moreover, in developing countries, poor agricultural technology and immature distribution systems are leading to food wastage and shortage.

3.2.5 Government involvement in agriculture sector

In Japan, where the cultivated land is small and resources are limited, in such a situation there should be a high awareness of food waste reduction and resource recycling. Various laws have been enforced in the individual and public sector, such as during Containers and Packaging Recycling Law and the Home Appliance Recycling Law, etc. Businesses that produce huge amounts of food waste annually in Japan are required to report to the competent minister the status of waste production, volume of waste control, recycling rate, etc. In addition, as there is a lot of food loss occurring from home, food loss including food education, environmental education, consumer education act and regulations have been included in the basic plan.⁸⁷

The Ministry of Agriculture, Forestry and Fisheries (MAFF) and the Ministry of the Environment (MOE) have set recycling targets, developed measures to promote recycling, and produced data on national food waste generation and recycling rates for food-related industries and businesses. Japan is well renowned on the food recycle management but the exception of food manufacturers, recycling rates in the food industry do not meet recycling targets especially in the case for restaurants. It indicates that every year large amount of food loss occurs from the restaurant side, it means the Japanese consumer is not much aware about the food losses. If we compare between developing and developed countries, we can find that the developed countries consumer level food loss rate is far higher than developing countries.⁸⁸ Generally, peoples are comparing the food waste only with the economic value. We have not yet developed the consciousness to understand the many other kinds of effects it has.

Japan has identified five lifecycle stages in the food supply chain where food waste may be present: *Agriculture production stage* (waste on farm level), *The storage and transportation stage* (during postharvest handling, storage and transportation before processing), *The commercialization stage* (manufacturing industries, wholesale, retail, catering and restaurant activities), *The household consumption stage* (household preparation and cooking), and *End-of-life stage* (including recycling for use as animal feed, compost, energy generation, and incineration and landfill treatment).It was estimated that a total of 37.86 million tons of food

⁸⁷Kawai (2017). pp. 210-213.

⁸⁸See, FAO(1994).

waste was generated in 2011, 3.81 million tons in the agricultural production stage, 3.95 million tons in the storage and transportation stage, 19.96 million tons in the commercial food stage, and 10.14 million tons at the household stage, each comprising 10%, 10%, 53% and 27% respectively.⁸⁹The involvement of the Japanese government in the agriculture and food industry is really tempting. In order to promote the recycling of food waste more effectively, the Japanese government has introduced a certification system for recycling business plans focusing on business clusters, known as "recycling loops". Nepalese government also should have learned from the Japan about participation in agriculture sector such as harvesting management, postharvest management, recycling management, agro-based program etc.

The Japanese government provides guaranteed prices for major vegetable crops, technical advice through research and services, and grants for the construction of farm roads, irrigation systems, fertilizer sheds, and the conversion of paddy fields into vegetable fields. Not only in the infrastructure sector the government of the Japan making rule and regulation for support the Japanese farmers such as high tariff on imported goods, limit on import amount, and some goods extremely prohibited to import. That kind of government supports are highly needed for today's Nepalese farmers.

Postharvest technology of vegetables, from harvest to consumption, has made rapid progress over the last three decades in Japan. It involves careful harvesting and sorting, strict standardization, and the development of suitable packaging materials, Mechanized pre-cooling facilities, refrigeration system, and clean display. The year-round supply system for vegetables established in recent years is supported by the following technologies. Use of cold-resistant and heat-resistant cultivars, Climate-dependent production: summer production in the highlands and average high latitudes and winter production in the warm southern coastal areas, Production under protected cultivation using glass house, plastic house, raw cover, and mulching, advanced transportation systems: packaging, pre-cooling systems, refrigerated transportation systems, paved roads, etc.

⁸⁹See, FAO(2011).

Agriculture is the mainstay of Nepalese economy and around 74% of Nepal's population are directly engaged in agriculture and more than 90 percent of population are indirectly involved (CBS, 2011),⁹⁰if we see the data of the 'Trade and Export Promotion Centre, 2019' Nepal import vegetable goods from foreign countries around 959,159 metric tons, and export around 25,297 metric tons. Export ratio is decreasing and import ratio is increasing year by year. This means Nepal is totally depending with the neighbor countries in agriculture (especially vegetable goods). It is not difficult to assume the system of the Nepalese agriculture.

In terms of food loss, the problem of postharvest loss cannot be separated. Food loss and postharvest loss are two wheels of the same chariot, so it is impossible to control food loss without controlling postharvest loss. Therefore, if the problem of postharvest loss can be solved, the problem of food loss can be solved by about 70 percent.

Less developed countries like Nepal the food loss that before reaches the consumer plate, which is called postharvest loss and losses rate is very high comparatively with the developed countries. The cycle of the postharvest and food loss is not only related at the farmer, retailer or only consumer level, the umbrella of this cycle is interrelated with all of us human activities so every person should contribute from their level to prevention for postharvest losses and food losses.

By providing education to the farmer, wholesaler or consumer level can reduce certain percent of losses, as well as it is necessary to implicate advanced technology i.e., packaging machines, transportation vehicles, cutting and drying machines, etc. Postharvest losses can also be minimized by establishing food related industries. Goods that can be consumed for a long time can be produced by processing the items that are not easily sold in the market. By setting up warehouses, food can be sold at higher market prices during the off-season, which can solve the problem of farmers who are forced to throw away their produce due to the lack of food market.

In Japan, local food movements have recently been promoted by governments and advocacy groups. These movements focus on the production of fresh food as closely as possible where it will be consumed, with less use of synthetic chemicals and more use of organic production

⁹⁰CBS (2011).

methods, thus promoting food safety. Japan's national topographical features and agricultural history have influenced the mix of small urban and rural land use in the surrounding areas.⁹¹

Most of the market area in Nepal is far from production farms which lead to high rate of postharvest loss as well as high cost of product. Since there is no transport vehicles equipped with refrigerators, the chance of food loss is relatively high during the transportation. Even when consumers pay enough, they are deprived of fresh food, which has a direct impact on their health. With the Consumer Awareness Program, if we are able to make consumers aware of their health issues, they will be attracted to the local product. If farmers find a market for their product, they will be motivated to engage in the agriculture field. Due to which postharvest losses can be controlled to some extent.

Due to the supply chain system, local farmers are forced to compete with outside producers, which is not good for local farmers and consumers. Farmers cannot get good prices for their produces and consumers cannot get fresh product. As a result, local people are discouraged from taking up agriculture. In the case of Nepal, Indian agricultural commodities dominate domestic production. As a result, farmers are overwhelmed by the agricultural profession and are trying to keep their children away from the agricultural profession.

3.2.6 Vegetable production in Japan

In Japan, domestic vegetable production accounts for 80 percent of demand and supply and vegetable imports for 20 percent.⁹² The main products produced in the country are cabbage, Radish and Onion. Of the imported vegetables are, onions accounted for 30% of total imports (90% of which are from China), and tomatoes accounted for 40% of total imports (20% of which are from the United States).

Vegetable production in Japan has declined after peaking in the 1980s the volume of vegetables produced in 2017 was 2.450.8 billion yen, which is 30% of Japan's total agricultural production. The planted area was about 410,000 hectares and the production volume was about 11.7 million tons, which is flat in recent years.

⁹¹Hara, et al.(2013). pp. 2-14.

⁹²Ministry of Agriculture, Forestry and Fisheries (2018).

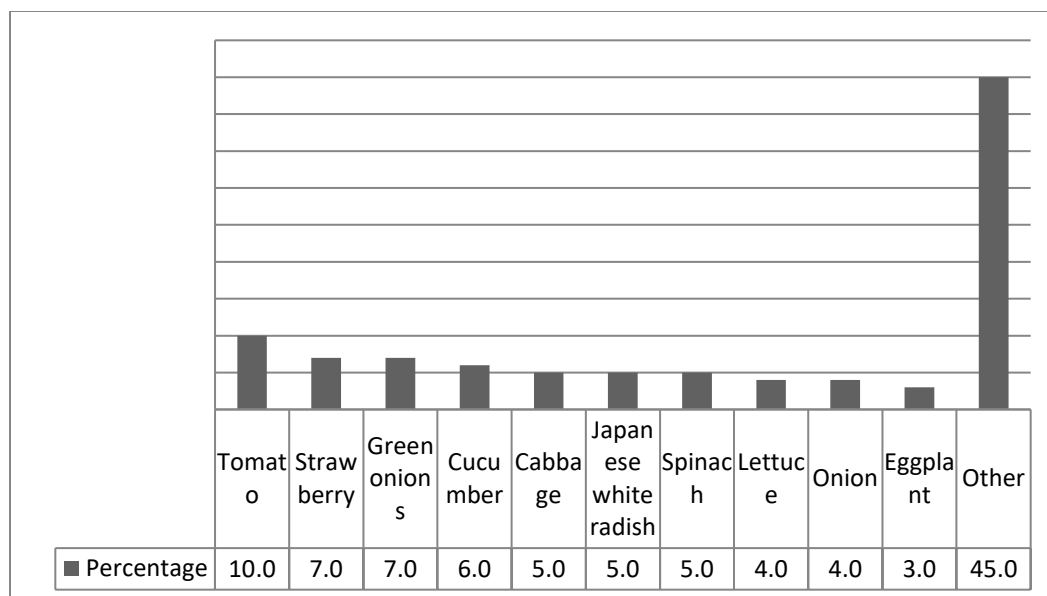


Figure: 3.2 Japan's vegetable production ratio in 2017 (by value), Source: Ministry of Agriculture Forestry and Fisheries . (2020). *Seisan nōgyō shotoku tōkei*. Retrieved from Ministry of Agriculture Forestry and Fisheries.

Measurements of vegetable farming are small on a national level, but measurements are large in key production areas, and agricultural incomes are also high. The distribution cost (sorting / packing labor cost, packaging material cost, and transportation cost) is in a large proportion of the main cost of vegetables.

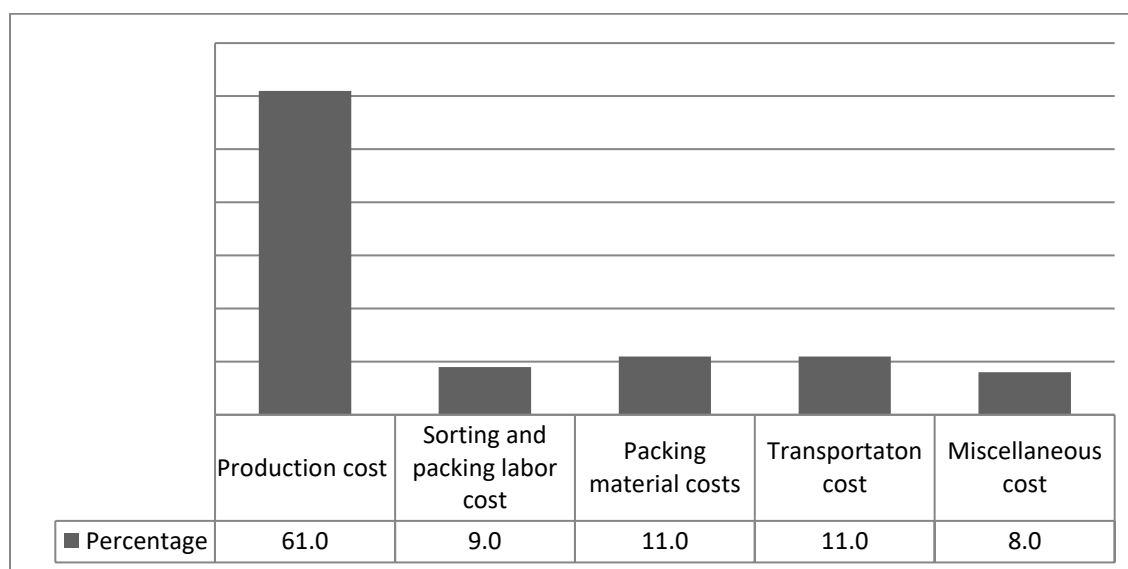


Figure: 3.3 Ratio of cost from production to sales, Source: Ministry of Agriculture Forestry and Fisheries (2017). *Shokuhin ryūtsū dankai betsu kakaku keisei chōsa*. Retrieved from Shokuhin ryūtsū dankai betsu kakaku keisei chōsa no gai yō.https://www.maff.go.jp/j/tokei/kouhyou/syokuhin_kakaku/gaiyou/index.html#12, cited on January 20, 2022.

Consumption of vegetables has declined in these recent years. In 2019, it rose slightly to 90 kilograms per person per year compared to the previous year.⁹³ According to the generation, the consumption of vegetables in all age groups has not met the target and especially in the age group of 20 to 30 years, the consumption of vegetables has decreased. But the United States, vegetable consumption has been on the rise since the 1980s. Consumption of vegetables in the United States has been higher than in Japan since the mid-1990.⁹⁴

Due to the growing population and increasing female labor participation, the number of large households has decreasing while the number of single- and double-income households has increased. At the same time, the time spent by women in housework is also decreasing. Lifestyle changes led to a sharp increase in demand for food outside the Heisei era, but in recent years it has remained the same. Meanwhile, the purchase price of cooked food has increased even when eating out. Consumption of fresh vegetables is declining, while salads, such as processed cooked foods, are increasing in the basements of supermarkets, convenience stores and department stores. Currently, eating out is flat, but the market size of ready-to-eat food is also increasing, especially in convenience stores and supermarkets.

The number of processed and commercial vegetables has been increasing and in recent times, it has been 60 percent of the total production.⁹⁵ The need for processed and commercial vegetables is not only for domestic consumption by real people and consumption, but also a high need for regular and fixed supply. The price of processed and commercial vegetables is often cheaper than domestic consumption. For processing and commercial use, the quality and standards for household consumption should be different. For this reason, in recent years, we have promoted

⁹³Stipp (2019). pp. 3-7.

⁹⁴Naka (2011). pp. 2-8.

⁹⁵Kashiwagi (2016). pp. 3-11.

the proliferation of species that have been given disease resistance to existing species with new characteristics and high processing suitability for processing and commercial use. For stable supply of processed and commercial vegetables, it is important to establish new supply routes through intermediaries to ensure stable supply throughout the year and facilitate contract transactions.

Vegetables tend to fluctuate in crops depending on the season and storage stability is weak, so prices fluctuate significantly due to fluctuations in supply. Additionally, since commodities are relatively easy to convert, the planted area is likely to fluctuate according to price fluctuations, and supply amounts fluctuate accordingly, and prices fluctuate further.

To provide a steady supply of vegetables to the consumers, the national government has formulated guidelines for demand and supply of vegetables across the country and the production sector and producers have planned production and transportation based on their own sales performance and approach. As a countermeasure against price increases and declines due to abundance, it will take measures such as speeding up shipping when prices rise, delaying shipping when prices fall, selling for processing, market isolation, etc.

With the recent changes in the consumer consciousness of food, there is a growing demand for safe and secure locally produced agriculture and products. On the other hand, large imports of cheap agricultural produce from abroad and rising production costs, fixed property taxes on agricultural land in urban areas, and a decline in the value of agricultural produce due to heavy assets, have led to a decline in profits. The burden of inheritance tax has discouraged people from starting farming and it is difficult to find a successor.

The capital has urged the national government to improve the system of urban agriculture and cultivable land and to revise the tax system in order to sustain sustainable urban agriculture in the coming days. In March 2015, Japan proposed a National Strategic Special Area for the Promotion of Urban Agriculture and the Improvement of the System for the Conservation of Urban Arable Land. In addition, the Ministry of Agriculture, Forest and Fisheries has set up a 'Study Group on Urban Agriculture Promotion' and the Ministry of Land, Infrastructure,

Transport and Tourism have set up a 'Social Capital Development Council City Plan' and a Historical Climate Sub-Committee.

3.2.7 Vegetable supply chain system in Japan

Vegetables and fruits contain variety of nutrients, such as vitamins and minerals, as well as non-nutrients (photochemical) such as dietary fiber, polyphenols, arylterpenoids, and isothiocyanates. They contain variety of antioxidant properties such as vitamin C, vitamin E, arylterpenoids, polyphenols (anthocyanins, chlorogenic acid, etc.), and isothiocyanate. In particular, Brassicaceae are thought to be effective in reducing the risk of lung cancer in men and colon cancer in women who do not smoke. It is also expected to reduce the risk of cataracts in men. Similarly, vegetables other than green and yellow are equally expected to have a gastric cancer risk reduction effect, and in terms of dietary fiber, those derived from vegetables and fruits are more. There is a high tendency to reduce the risk of death. Additionally, it has been reported that consumption of 100 grams of yellow / red vegetables and green onions per day reduces body weight by 25 grams.⁹⁶

In light of the current state of domestic distribution, the proportion of grocery purchases from general retailers is declining, and the proportion from supermarkets, including collective retailers, is increasing. Additionally, the proportion of vegetable auctions and bidding transactions in the central wholesale markets has been declining, and bilateral transactions in which wholesalers set prices and quantities with buyers. Additionally, there have been cases of large retailers operating their own farms, and the number of cases of handling vegetables from their own farms as private brand (PB) products has been increasing.

Japan has undergone significant changes in distribution structure in recent years, and there is an urgent need to develop a vegetable production system that responds to these changes. In the future, consumption is expected to decline in the long run due to declining population, but on the other hand, due to conversion to vegetables, there are also cases of change in consumer interest. The time has come for those involved in vegetable production, distribution, processing, sales, etc. to work together to stimulate domestic and foreign demand, as well as to respond appropriately to the real needs of consumers by making appropriate plantings based on crop fluctuations and

⁹⁶Tohill (2005).

demand trends, consumer tastes and health changes. Because of this, it has become important to build smart food chains that enable optimization of the entire supply chain by combining data from production to distribution and consumption. As a data-driven smart production system that supplies primary products in response to the needs of real consumers, an accurate transportation system that combines development uniformity technology and development simulation technology with field image sensing technology. Mobile transport is being operated for agricultural work using automation technology and converted agricultural machinery. Furthermore, on the distribution side, we need to aim to provide high quality vegetables to the consumers and to predict and control the appropriate quality as per the demand, as well as to reduce food loss by developing freshness maintaining technologies.

In addition, refrigeration storage facilities have been set up near the consumption area to avoid risks associated with uninterrupted supply due to seasonal disasters, etc., and facilities have been developed to supplement stock points at points between the production area and the consumption area.

3.2.8 Food waste in Japan

First of all, it is better to have knowledge about food loss and food waste. There is no specific definition of 'food loss or waste'. According to the FAO, 'food loss and waste' generally refers to the reduction in the mass (quantitative) or nutritional value (qualitative) of food (edible parts) throughout the supply chain intended for human consumption.⁹⁷

Actually, there is not any certain definition about food loss and food waste but generally food loss upstream in the supply chain, crops are often due to lack of knowledge and skills at the stages of harvesting, storage, transportation and processing. Food waste occurs mainly in developed countries. At the wholesale, retail, and consumption stages downstream of the supply chain, business practices and consumer values and economic ideas are often the cause.

In recent years, there has been a growing awareness around the world of issues related to food losses and food wastes. Despite providing food to 7.6 billion people worldwide, around 811

⁹⁷FAO (2014).

million people suffering from starving.⁹⁸ On the other hand, global food loss and food waste is about 1.3 billion tons per year.⁹⁹ This means that about one third of the 4 billion tons of food produced for human consumption is wasted. In Japan approximately 6.5 million tons of the food waste occurs in every year.¹⁰⁰ It is estimated that the amount of food loss generated by households is about half of that, about 2.8 million tons, and here a family of four throws away food worth about 60,000 yen each year. But here are not only foods are wasted but also wasted fuel be used to dispose of discarded food, which contributes to global warming, but the cost of its disposal will be borne by taxes. These cycles have been influenced negatively in the human life.¹⁰¹

World Food Program (WFP) provides foods for the under developed countries, annual amount of food aid is about 3.8 million tons,¹⁰² which means that Japan alone is wasting almost double amount of food aid provided by WFP. Additionally, the world's population is growing and is expected to reach 9.5 billion by 2050. Constant food waste can increase the amount of hunger.¹⁰³

In Japan, food loss and food waste are often discussed in terms of "obesity" and corrective measures are taken from that perspective. In the first time the concept of "Mottainai" which was born in the Edo period in the early 17th century. During this time of the Taihei era, Japan's population increased. As a result, the proportion of Japanese population to world population was 4.8% at the beginning of the 18th century. However, at that time Japan had only 0.33% of the world's cultivable land, and all the burden of population growth had to be borne in that land.¹⁰⁴ At that time people were suffering from not only food but also lack of biological resources such as heating and cooking fuels, textile raw materials and burning oil, etc. Then, in the Meiji era, due to the expansion of coal and rapid growth of industry, further population growth took place through the development of urban areas. When the economy grows at a high rate, the term "Mottainai" refers to the fact that resources are limited and we need to consider environmental issues instead of the wisdom needed to survive.

⁹⁸World Health Orgination (2019).

⁹⁹Gustavsson, et al. (2011b). pp. 10-11.

¹⁰⁰Food and Agriculture Orgination of the United state (2011). pp. 3-10.

¹⁰¹Ministry of the Environment (2012).

¹⁰²World Food Programme (2017). P. 4.

¹⁰³Ministry of Agriculture, Forestry and Fisheries (2019b).

¹⁰⁴Kawashima (2010). pp. 195-216.

In Japan, about more than 50 percent of wasted food is reused as animal feed.¹⁰⁵ It helps to recycle a few percent of the food that is being wasted. But if we look at the economic value and cost of the product, the producer estimates the loss of food before the loss and makes the goods more expensive by including the price in the product. The result of this type of practice is that the quality and price of the product do not match and customers are reluctant to buy, which means that there is a possibility of further food loss.

Table No. 3.1 per capita food losses ratio from 2012 to 2016

Years	2012	2013	2014	2015	2016
Food losses in (\$ millions)	6.42	6.32	6.21	6.46	6.43
Per capita losses	50 kg	50 kg	49 kg	51 kg	51 kg

Source: Internet

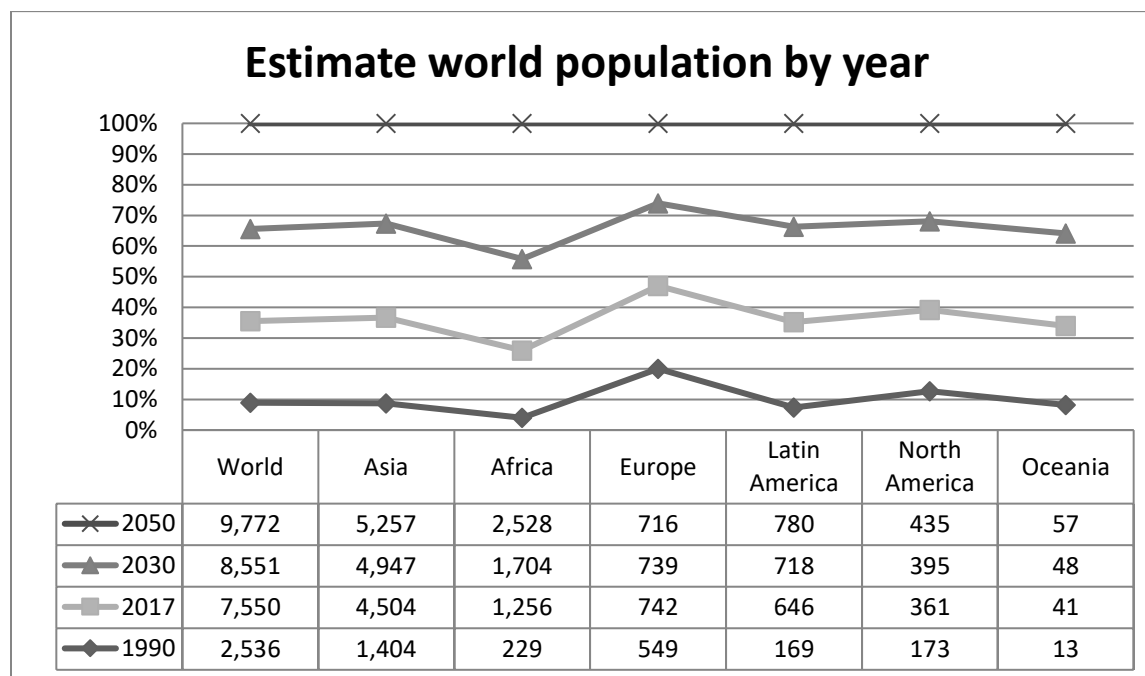


Figure: 3.4 Estimated world population by 2050 in million, Sources: World Population Prospects

¹⁰⁵Ministry of Agriculture, Forestry and Fisheries. (2014). pp. 1-10.

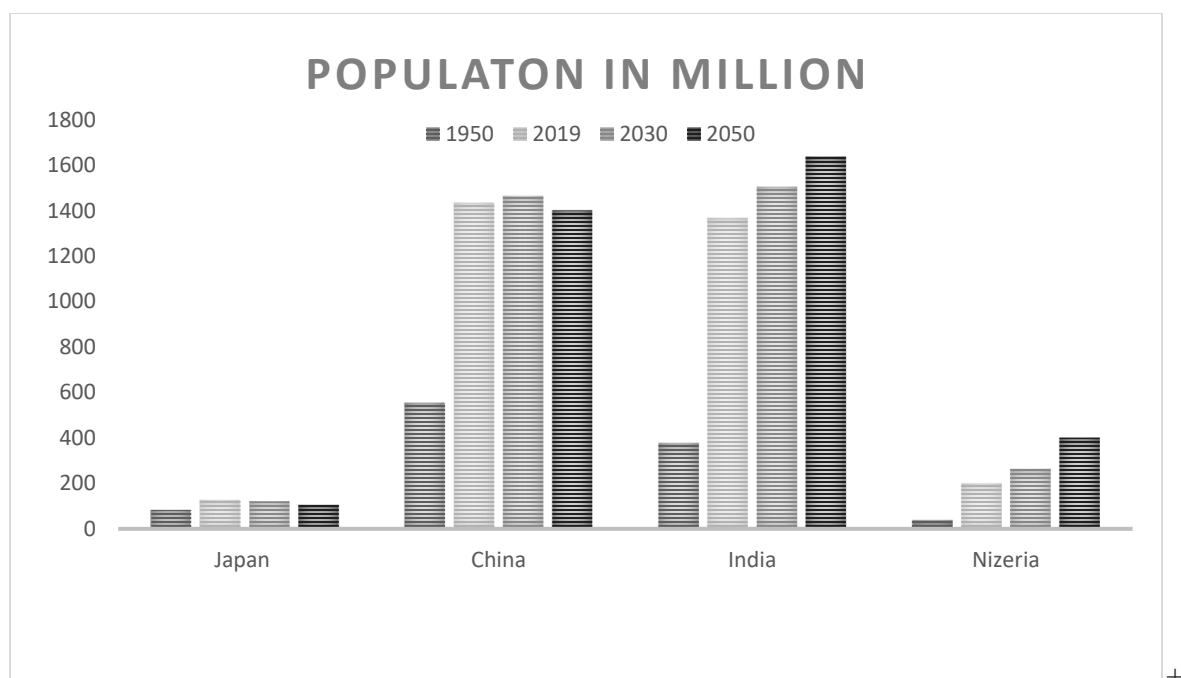


Figure: 3.5 Estimated countries population by 2050, Source: Country population prospects

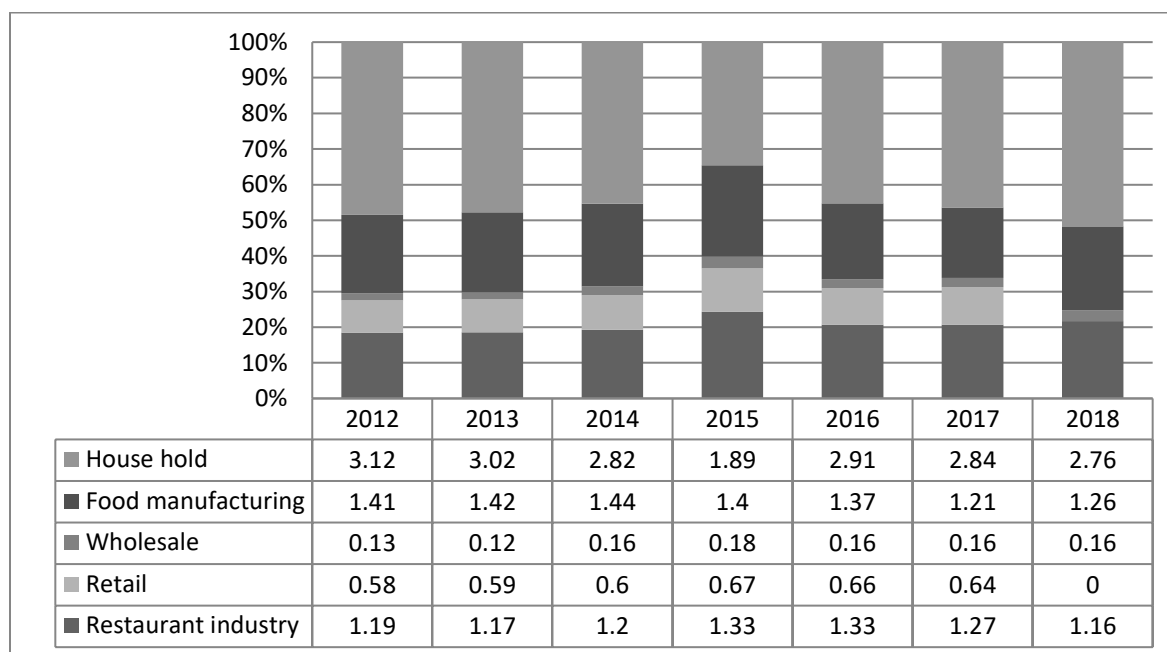


Figure: 3.6 Japan's food losses from 2012-18 (in millions), Source: Ministry of Agriculture, Forestry and Fisheries (2018).

Despite the fact that many people in the world are suffering from malnutrition, Japan is wasting large quantities of edible foods, which is the need in Japan to address very seriously as much as possible. As a basic approach to reducing food waste, there is a need to raise public awareness that food is not wasted and that every level of the people can address this problem independently from their own point of view and respond to society as a whole. To implement this, every effort should be made to use edible foods as much as possible without discarding them.

In fact, food losses occur not only in developed countries but it is becoming the same problem in developing countries. However, the reasons for food loss are differences between developed and developing countries. Most of the food losses in developing countries are caused by lack of infrastructure, technology and knowledge, but in developed countries consumer behavior, culture and schedule of life are playing major roles for the food loss. Japan is where the food losses rate is very high among the developed countries. Agriculture is facing unprecedented challenges in feeding the world's population. More importantly, pressure is mounting on agriculture. Food loss can occur at several points along the food chain, however, food loss at the consumer level is often overlooked which is directly impacting on sustainability. Consumer level food loss is often influenced by cultural, religious, economic and social also other kind of matters. Japanese government has developed incentives to promote the recycling of food waste. For instance, a certification system was introduced for animal feed comprised of food waste (called “Eco-feed”), also there are several similar recycling programs. However, there appears not to be any programs for consumer behavior. Consumer awareness program and appropriate rules and regulations can be more effective in reducing food waste at the consumer level.

There are several questions rises with these problems and there are many related factors behind of that problem. There are two main causes for food losses in Japan. One of them is trade-related food losses, such as food left over from supermarkets and convenience stores, leftovers from restaurants, unsold products unsold or returned items in retail stores. Another is the loss of household food, such as food left over from over-cooking at home, discarded even if purchased, and excessive grinding during cooking. Busy schedule is also one of the major reasons of the food wastage in Japan. Japan is one of the busiest countries of the world. People do not have enough time to cook lunch or dinner, office worker (salary man) usually leaves their home for

office around 7:30- 8:30 AM, so most of the officer take lunch box (弁当) from convinces store as a lunch. The store owner order a lot of lunch box (弁当) but most of the time the stock will not clear it means the food should throw after cross the expired date. Because of that one of the biggest food losses occurs from convinces store in the Japan.

Although the world's malnourished population is declining, about 800 million people still suffer from malnutrition, which means that one in nine people in the world is malnourished. In developing countries, malnutrition kills every year about five million children under the age of five. On the other hand, the fact that large-scale food losses occur every year in developed countries, including Japan, this indicates an imbalance in the world's economic and social systems.

In convenience stores food losses arise about 15,000 yen per store per day. It has an annual cost of 5.3 million yen and weighs 4.1 tons. There are about 55,000 convenience stores nationwide;¹⁰⁶the annual food loss nationwide is estimated at 22.5 million tons. There are also food losses that occur while making lunch boxes for the convenience stores, this is called hidden food loss, if including all kinds of food losses, and it is expected actual food losses from convenience stores more than the published data.¹⁰⁷

Japan's calorie-based food self-sufficiency rate was 38% in fiscal year 2016.¹⁰⁸These figures show the food self-sufficiency rates of other major developed countries, Canada (264%), Australia (223%), USA (130%), and France (127%). It also shows that Japan's food self-sufficiency rate is the lowest among developed countries. Although Japan imports large quantities of food, Japan's annual food waste is about approximately 18 million tons of foods annually which are around 39 percent of the national total production.¹⁰⁹In recent year the Japan's government, institutions and related organizations have been paying attention to reduce food discard. Also, several strategies and law have been adapted to tackle this problem. At the top of the world's food waste list are three developed countries, including Japan, the United

¹⁰⁶Francis (2020).

¹⁰⁷Ministry of Agriculture, Forestry and Fisheries (2015b).

¹⁰⁸Ministry of Agriculture, Forestry and Fisheries (2016).

¹⁰⁹Ministry of Agriculture, Forestry and Fisheries (2013a).

States and the United Kingdom, each discarding 30-40% of their annual food production.¹¹⁰ The objectives of the Recycling law are increase the recycling rate discarded food to 48 percent by 2006, but it already been surpassed in 2005.¹¹¹ While developed countries are discarding huge amount of the food it is goes to negative message to the world. Where the developed countries are discarding edible food and other hand peoples of the underdeveloped countries are suffering from the starving. The problem is being more and more complicated and it has to be addressed as soon as possible otherwise this could lead another big catastrophe. Many kinds of violence are taking place today due to food shortage. If the problem is not solved in time, it would turn into another catastrophe.

It was assumed that Japan discarded 18 million tons of food annually, of which 7-8 million tons ware edible at that moment they were disposed of. Of which 3 to 4 million tons of food discard was from food industries and another 2 to 4 million tons was from the individual house hold.¹¹²

In recent years, food waste from convenience stores has become a major problem in Japan. There are more than 55,000 convenience stores all over the countries, and the average food loss per day is equivalent to about 20,000 Japanese Yen per store. 40-60 percent of the discarded food from convenience stores goes for animal food especially for the pork farm; rest of the food is being completely discarded. Food loss is not only economic loss but indirectly it has involved several things like, effort of the farmers, water, chemical (which is not good for the human health and environment or soil but it has to be used to prevent the insect during the cultivation and storage period), etc.

Japan's food recycling law was enacted on May 1, 2001, and was last amended on June 13, 2007. According to this law the related ministry will make efforts to promote the reuse of food recycling resources, collect information, organize and use it and secure the funds required for conducting public relations activities. Under the law, a food-related business that generates large amounts of food discard must report to the relevant agencies about the amount of food waste produced every year and the status of recycling efforts. The concerned ministry will monitor the

¹¹⁰Melikoglu, et al. (2013). pp. 157-161.

¹¹¹Ministry of Agriculture, Forestry and Fisheries (2017b). pp. 5-16.

¹¹²Ministry of Agriculture, Forestry and Fisheries (2013b).

food traders and will give instructions and suggestions when it is required. The Japanese government enacted the Recycling Act in 2001 with the aim of reducing food waste. The main objective of this law is food will be reused in several ways which are going to be wasted.¹¹³

3.2.9 Food wasted in other countries

The first of the Sustainable Development Goals (SDGs) is to eradicate poverty from the world by 2030, and the second one is to ensure that no one is hungry. World Food Day 2020 calls for global unity to free the population from food crisis, save the most vulnerable, and make the food system more flexible and powerful. It requires better social protection, innovation, digitization and sustainable agricultural practices to protect the Earth's natural resources, our health and climate. But, of course, despite these precarious times, from healthy choices to increasing overall demand for nutritious foods, preventing spoilage habits, and participating in global unity efforts. The role that we all play is very important. Now we need to think about what we are eating and how it affects our health and the health of the planet. The large amount of food thrown at a party should be reduced. Before throwing food, we need to remember "farm-to-table", the farmer's land-to-table journey, the workforce, the energy used there, and the carbon emissions it produces. On the one hand, peoples in the world are getting sick by eating too much and on the other hand, poor people are suffering from malnutrition due to lack of food. The time has come to respect our diet in order to overcome this inequality between people.

Many countries are suffering from hunger. On the other hand, many people aren't even thinking about wasting food. A UN report on food waste around the world has been revealed. This can be spectacular for those who dispose of food. According to a UN report, in 2019, it is estimated that 9.31 million tons of food wasted worldwide. The amount of food wasted in Indian households is estimated at 68.7 million tones, of which 61% is wasted from grocery stores, 26% from food distributors and 13% from the retail sector. According to the report, this shows that 17 percent of the world's total food production is wasted. That amount is estimated to be equal to 23 million full-load trucks with a capacity of 40 tons.¹¹⁴

¹¹³Ministry of Agriculture, Forestry and Fisheries (2021a).

¹¹⁴Nanda, et al. (2012). pp. 9-27.

It is believed that the Covid 19 pandemic makes it impossible for 821 million people to get the right amount of food.¹¹⁵ For this reason, consumers need to help reduce food waste. The report found that 11% of the food available for total consumption was wasted at home. India's position is superior to its neighbors when it comes to food disposal. Indian families waste 50 kg of food per person each year and the same figure is 74 kg in Pakistan.¹¹⁶

Pakistan has also not been spared from the problem of food wastage. The large number of the Pakistanis is facing malnutrition and food insecurity, but a tremendous amount of the edible foods is turning into the garbage every year due to the unmanaged food supply chain. Immediate action and consideration are needed to reduce the effects of food waste for the food security in Pakistan.

In Pakistan, about 30 percent of the total production i.e., 36 million tones food is wasted annually.¹¹⁷ Lack of inadequate storage facilities causes substantial grain spoilage due to rats and other animals. The amount of spoilage in fruits and vegetables is more than grains. The report titled 'Global Food Waste Not Want Not' said that 40 percent of fruits and vegetables are waste before reaching the consumer level due to lack of refrigerator installed transport facilities, bad roads, inclement weather and corruption.¹¹⁸

Many countries have not yet begun to figure out how much food they are throwing away. The government needs to monitor it so that the clear situation becomes clear. The United Nations is working to find out how much food was wasted before it reached humans. Once this is known, more accurate numbers will be revealed. The world wastes 121 kg of food per person each year. The proportion of households in these is 74 kg.¹¹⁹ According to the report, per capita food waste is highest each year in Western Asia and sub-Saharan African countries. Compared to them, the rate is much lower in South Asian countries and most European and North American countries. This report breaks down the old notion that more food is wasted in developed countries. In South Asian countries, Afghanistan is at the top of the list with a weight of 82 kg. This is followed by

¹¹⁵World Food Programme (2019). PP.1-3.

¹¹⁶Forbes, et al. (2021). pp. 41-75.

¹¹⁷Ghauri, W. U. (2018). pp. 7-8.

¹¹⁸Fox (2013). pp. 7-11.

¹¹⁹Forbes, et al. (2021). pp. 41-75.

Nepal at 79 kg, Sri Lanka at 76 kg and Pakistan at 74 kg and Bangladesh at 65 kg. India is the last ranked in South Asia on the list of countries that waste per capita food each year. The amount of food wasted in Indian households is estimated to be 50 kg per person per year.¹²⁰

The challenge of providing adequate, safe and nutritious food to all for the joint contribution of the United Nations agencies involved in strengthening the food security situation, international organizations and development partners, regional organizations and indigenous organizations, productive working-class farmers, agri-entrepreneurs and businessmen, civil society Is a global issue.

More than 20 million tons of wheat is wasted in India every year due to lack of better storage facilities, says a new global report. According to a global report by the Institution of Mechanical Engineers (IME) on food waste, about half of the world's grain production is of no use to humans. The report on food grain waste states, "In large developing countries like India, grain wastage is high. According to the report, about 21 million tons of grain is wasted in India, which is equivalent to the entire grain production of Australia. On the other hand, in neighboring Pakistan, about 16 per cent of the total production, i.e., 3.2 million tones are wasted annually. Insufficient storage lack of facilities spoils a lot of grain due to rats and other animals. Fruits and vegetables spoil more than grains, the report said. The report titled 'Global Food Waste Not Want Not' released on Thursday states that due to lack of cool transport facilities in India, bad roads, unfavorable weather and corruption, 40 per cent of fruits reach from producer to consumer and Vegetables are wasted. The report says about India that reducing and controlling grain waste there is beyond the reach of the average farmer. Distributors and consumers cannot do anything special in this. For this, the entire infrastructural facilities have to be improved. The report calls on the governments of developing countries to adopt innovative technologies in the field of food storage facilities.

China has 20 percent of the global population, but the arable land is only 7 percent,¹²¹ which means China has to know the importance of food production and play the effective action of how

¹²⁰ Forbes, et al. (2021). pp. 41-75.

¹²¹ Brown (1994). 57-62.

to minimize losses. China has remarkable success in increasing agricultural production and agri-modern technology. Despite all those things, China is facing a big problem of food wastage.

Food waste from the consumer level is also one big issue of food wastage in China. Food waste at the consumer stage occurs in the household and out of the house. According to the FAO much more food wastage occurs at consumer level in high income countries than medium- income and less-income.¹²² Food wastage at the consumer level in China is expected to increase because of the rapid growth of urbanization.

The Chinese government launched the campaign called 'clean plate' with the purpose to reduce food waste. Despite the all effort of the government, it is estimated that annually around 350 million tons of farm product, or about 27%, is discarded by retailers, restaurants or consumers.¹²³

We can learn a lesson from this, to solve the food losses problem. The government alone cannot do anything, so every person should be responsible and realize the importance of the food loss problem.

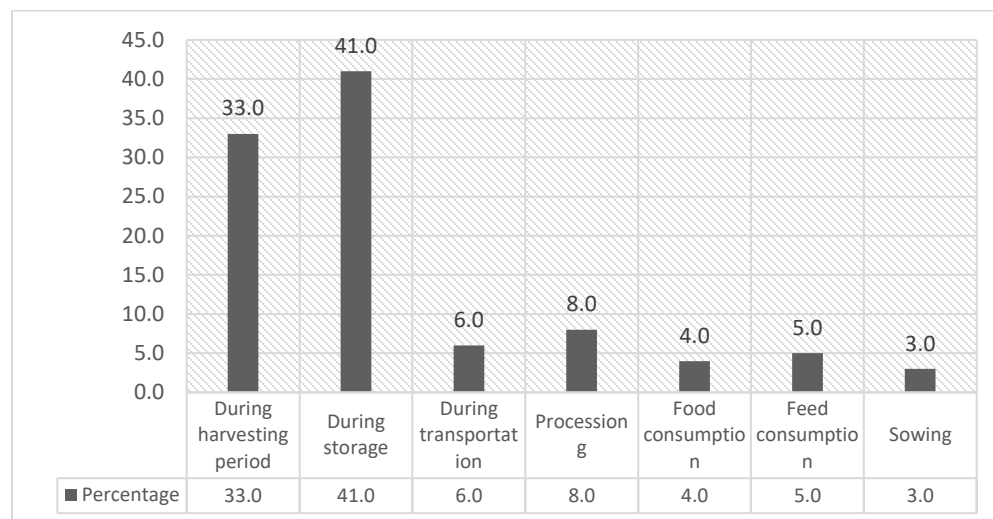


Figure: 3.7 Food losses in different stage in China, Sources: Internet¹²⁴

¹²²Gustavsson, et al. (2011).

¹²³Marchisio (2020).

¹²⁴Qin (2015). pp. 159-162.

From this table, it is clear that China has been facing big losses during harvesting time and storage period. Nepal and other developing countries also have almost the same situation as the china.

Every year, the Food and Agriculture Organization of the United Nations (FAO) observes October 16 as World Food Day. The slogan for this year's World Food Day is 'Grow Norris, Sustain Together'. It has been 75 years since this day was celebrated but the number of hungry people has not decreased worldwide, it is increasing. Many people in the world today are still struggling to cope up with starving.

The world's population is predicted to reach 9.5 billion by 2050. Until then, most people will live in developing countries. If a proper solution is not found in time, it is certain that there will be a big challenge to feed the pressure of the rising population. Each will eat an average of 12 percent more than in 2000. The Food and Agriculture Organization of the United Nations estimates that consumption of non-vegetarian foods will double. This means that food must be increase by 70 percent in the first half of this century.¹²⁵On the one hand, there are people in the world who have a lot of food and have a lot of food thrown in their house. On the other hand, there are plenty of people in developing countries who do not even have a single meal.

India is the second most populous and socioeconomically diverse country in the world. The gap between the economy and the population has been a big problem in recent years. The hunger and the food waste rate are more than assumed is one example of an economic gap. India produces an ample number of different types of the foods including seasonal and unseasonal. Despite the huge amount of food production, India ranks 94th out of the 107 countries in 2020 in the hunger index. From this statistical data we can simply assume that India is suffering from the food waste problem. The postharvest loss in 2014 was equivalent to \$ 15.19 billion.¹²⁶This was 0.6 percent of the country's GDP and equivalent to two and half times higher than the budget of the Ministry of Agriculture and Finance Welfare. According to the Indian government 22 percent of Indians live under the below poverty line. FAO says in 'The State of Food Security and Nutrition in the

¹²⁵Food and Agriculture Organization (2009). pp. 2-4.

¹²⁶Jha, et al. (2015). pp. 93-99.

world, 2017' report 190.7 million people are undernourished, this is the scarcely problem of India.

Several factors, such as, Weddings events, restaurants, hotels and houses are majorly responsible for the food loss in India.¹²⁷ Apart from this, many other factors are also responsible such as postharvest activities, consumer behavior, packaging material, transportation method and vehicle and so on.¹²⁸ All those factors of the food waste can be managed for this. First of all, we have to respect the food, and we have to keep in our mind always that someone somewhere is suffering from starvation. In parties and other kinds of ceremonies or events people cook far more than required because they want to show the guest the economic status is strength or for the other kinds of social show off. Somehow the tradition is also responsible for the food waste.

Food waste problem is not only in India but it is a common problem of the world. According to the FAO one third of the food produced in the United States has never been eaten.¹²⁹ Food waste is not only waste of the food, manpower, natural resources, and time and money also spoils along with the food waste. In the United States it is estimated that every year more than one-fourth of the drinking water lost for irrigation to agriculture crops which are never be consumed.¹³⁰ It is estimated United States food loss ranges from 120-125 million metric ton, or per person capital rate is 223-286 kg in a year.¹³¹

There are several aspects to consider about the food losses and wastage, in Brazil food losses occur in agriculture processes or technical limitations are major factors.¹³² Brazil, where is the food losses are affected by consumer behavior.¹³³ During the selection process on the market huge amounts of the food loss occur mostly in the highly perishable goods such as tomato, cauliflower, etc.

¹²⁷Bharucha, (2018).

¹²⁸Thacker, H. (2018). pp. 1-5.

¹²⁹Food and Agriculture Organization of the United Nations (2019).

¹³⁰Kenny, et al. (2021).

¹³¹Commission for Environmental Cooperation (2017). pp. 11-21.

¹³²Ruviaro, et al. (2020). pp. 70-78.

¹³³Alexander, et al. (2017). pp. 190-200.

Food loss in household, restaurant and other party events mostly occurs in developed countries but the case of the developing countries food loss occurs in pre harvesting and post harvesting period due to the lack of infrastructure, education, and other kinds of facilities.

3.3 Materials and Methods

Present study (postharvest practice and food losses in Japan) was conducted with both a secondary data collection and primary data collection method, primary data was collected by questionnaires method with farmers, suppliers (wholesalers), and retailers and secondary data was collected with published and unpublished books and other internet sources. In the case of the primary data collection, 10 supermarkets, 5 vegetable shops, 8 collection centers (suppliers) and 25 farmers were included. In all these areas, the postharvest losses have occurred by different reasons in different stages. The total losses at the farmer's side were 7.5 percent, 3.5 percent was at the supplier's side, 6 percent at market. The duration of the survey was 5 months (Oct 2021 to March 2022). The reason for choosing those provinces and small farmers is it is easy to compare with Nepalese farmers and the tools and methods that Japanese farmers use during harvesting. Also, this will be easy to introduce those materials to Nepalese farmers, so this survey chose Japanese small and medium size farmers for the study.

3.3.1 Descriptions of study area

Three main prefectures of the Japan had been chosen for the survey; those are follows.

Saitama prefecture

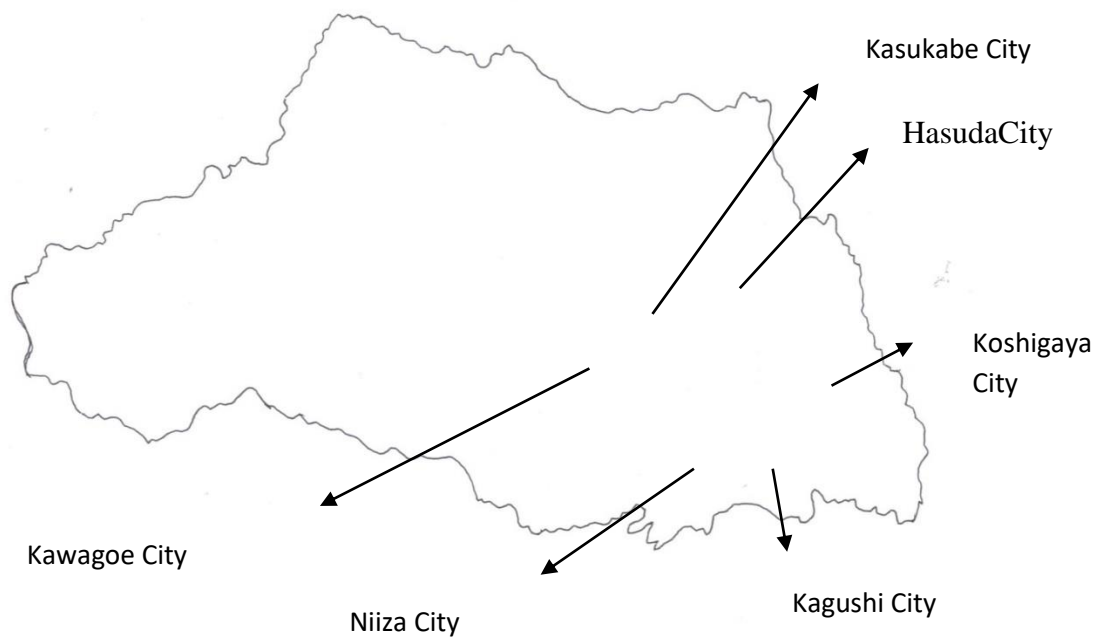


Figure: 3.8 Map of survey area in Saitama Prefecture, Source: Handmade map

Saitama is an inland prefecture, and it is around 100 km from the sea. The proportion of rivers within the prefecture's area is 3.9%, the highest in Japan. The population is about 7.27 million, 5.8% of the national population, the fifth largest in the country, and the average age is 45.4 years, the sixth and youngest prefecture in the country. The area under cultivation is 74,500 hectares, the 16th largest in Japan, with 41,300 hectares of paddy land and 33,200 hectares of farmland. The number of agricultural management bodies is 37,484, which is the 14th largest in the country, and the total number of agricultural households is 64,178, which is in the eighth place. The number of certified farmers is 5,079, which is the 18th largest in the country, of which 406 are corporations.¹³⁴

Kanagawa prefecture

¹³⁴Ministry of Agriculture, Forestry and Fisheries (2019a).

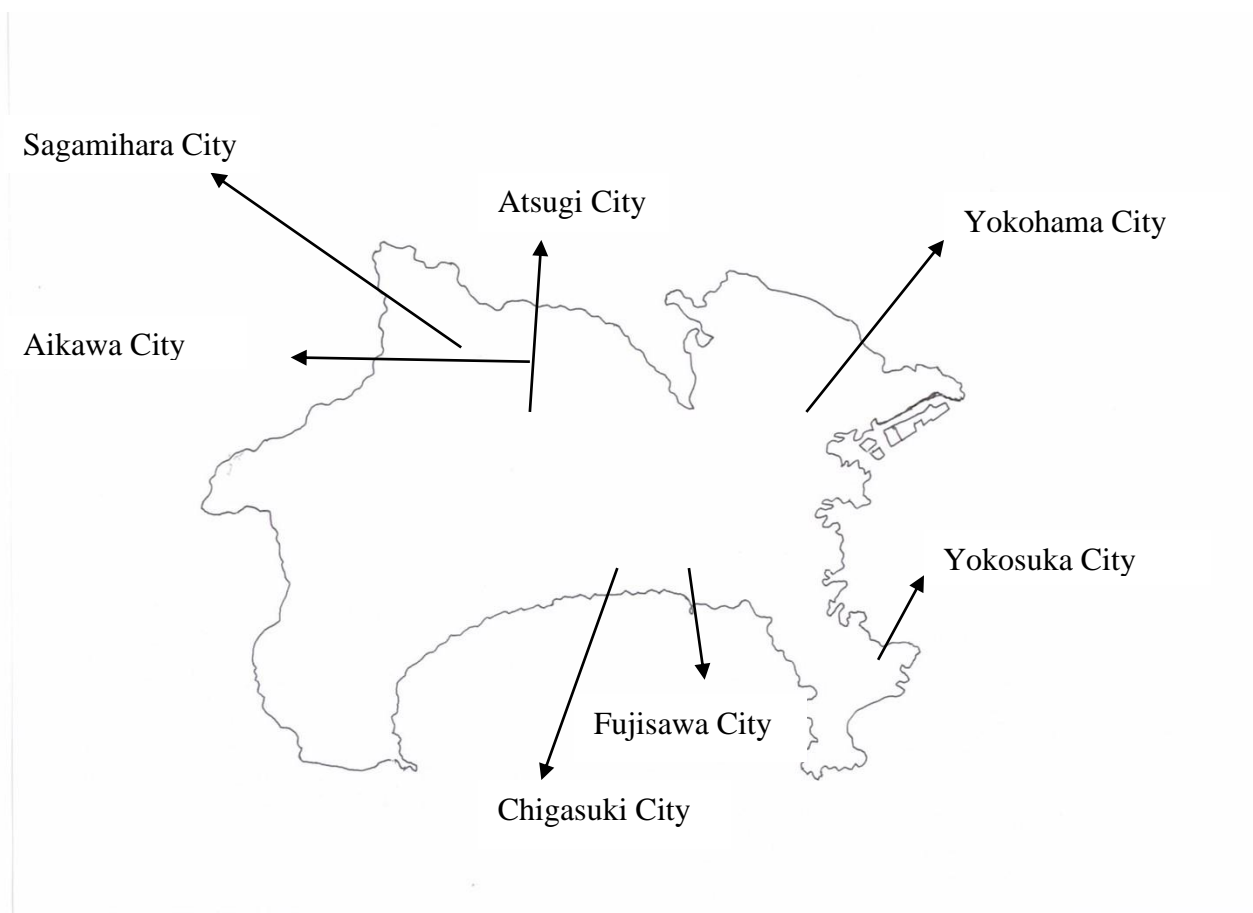


Figure: 3.9 Map of survey area in Kanagawa prefecture, Source: Handmade map

In Kanagawa prefecture the area under cultivation is 18,800 hectares, of which 80% or 15,100 hectares are farms. The total number of agricultural households is around 24,552, of which 3,514 are major agricultural households, ranking 31st in the country. The number of major agricultural workers is 20,302, of whom 60%, or 12,276, are 65 years of age or older.¹³⁵

The number of business establishments in Kanagawa prefecture is about 290,000, the number of employees is 3.46 million, and the number of companies is about 200,000, all of which is the fourth largest in Japan. In agriculture, the per capita area of cultivable land is 0.8 hectare, which

¹³⁵Ministry of Agriculture, Forestry and Fisheries (2015a). pp. 1-7.

is 2.1 hectare of national average. Arable land has a high proportion of 80% of the area, which is more than the national average of 46%.¹³⁶

In the Kanagawa prefecture agricultural output is around 69.7 billion yen which is 38th largest in Japan, 36 billion yen for vegetables, 14.6 billion yen for livestock and 8.2 billion yen for fruits. In terms of agricultural and livestock production, pansy (fluid plant) is second in the country, plum, kiwi fruit and squash are fourth and radish is fifth. In the business of production from farmers, the annual sales of the office of direct sales of agricultural products are 28.4 billion yen, which is the 14th largest in the country.

Tokyo prefecture

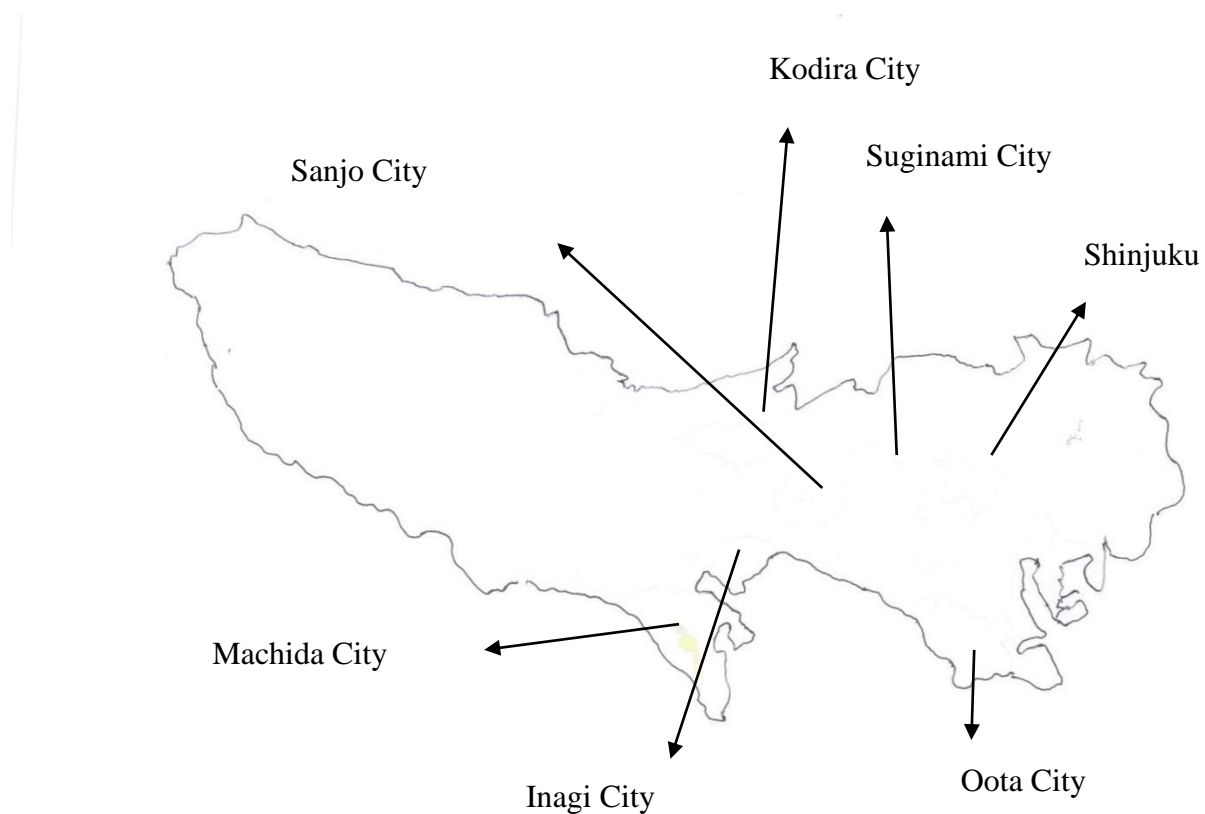


Figure: 3.10 Map of survey area of Tokyo Prefecture, Source: Handmade map

¹³⁶Ministry of Agriculture, Forestry and Fisheries (2021b).

Of Tokyo's 2,194 square kilometers, 8,000 hectares are arable land. Fruits, vegetables and flowers represent only 2 percent of the total arable land. Most of the city is covered with buildings and other types of infrastructure. According to A.... Only in Tokyo ... farmers are farming and all of them are over 65 years old. Based on this scenario, we can assume that the future of Tokyo's agriculture may be vanishing with those older farmers.

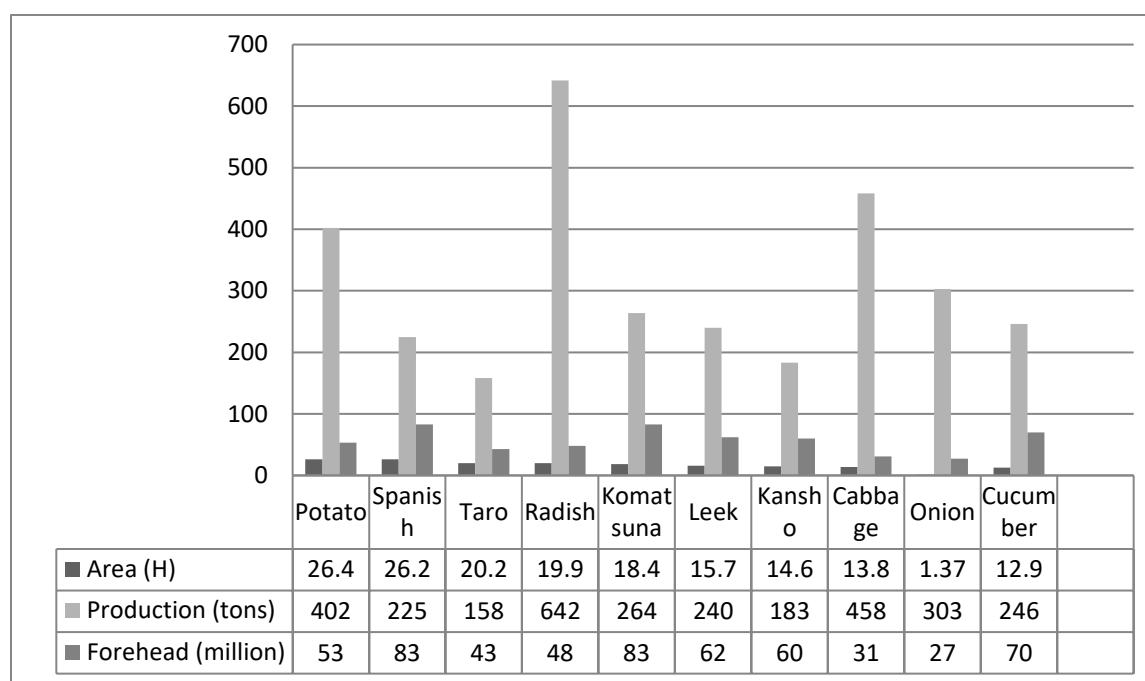


Figure: 3.11 Main vegetable production information in Tokyo prefecture, Source: Ministry of Agriculture, Forestry and Fisheries

The questionnaire survey was conducted at 8 supermarkets, 5 vegetable shops and 10 collection centers in different places of Tokyo, Kanagawa and Saitama prefecture. The supermarket was managed and owned by Japanese and the vegetable shops were operated by foreigners. In the case of supermarkets, the loss of vegetables was minimal, with perishable vegetables such as tomatoes and greens being slightly higher, while losses in other common vegetables were very low.

The supermarket and vegetable market found that the same vegetable with different qualities was supplied in the market channel based on their demands. It is found that with high quality

vegetables are supplied to the supermarket and in the vegetable market, vegetables were a little bit low quality.

Considering the importance of vegetables in supermarkets, it was found that slightly injured vegetables were kept in a separate place and sold at a cheaper price than healthy vegetables. But looking at the condition of the vegetable market, the injured vegetables were also sold along with other vegetables. As a result, even healthy vegetables are likely to spoil quickly.

Out of the total loss of 5 percent in the supermarket, the following losses were generated in different types of vegetables.

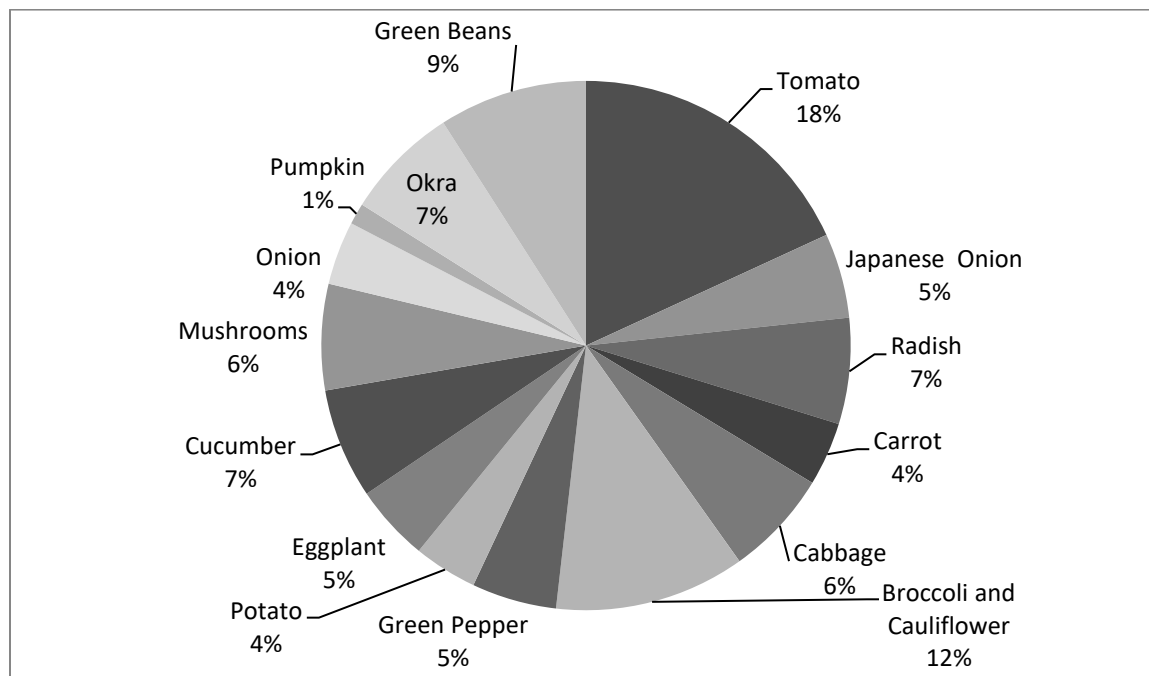


Figure: 3.12 Losses generated in different types of vegetables at super market by volume,
Source: Bhandari survey in 2021-2022

Most of the vegetables that are kept in the display for sale are usually packed in the store. In the supermarket losses have found that 40 percent of the total loss arises during packaging, 10 percent losses during transportation, 33 percent losses have occurred during the sales processing and the rest of 17 percent losses occurred during storage.

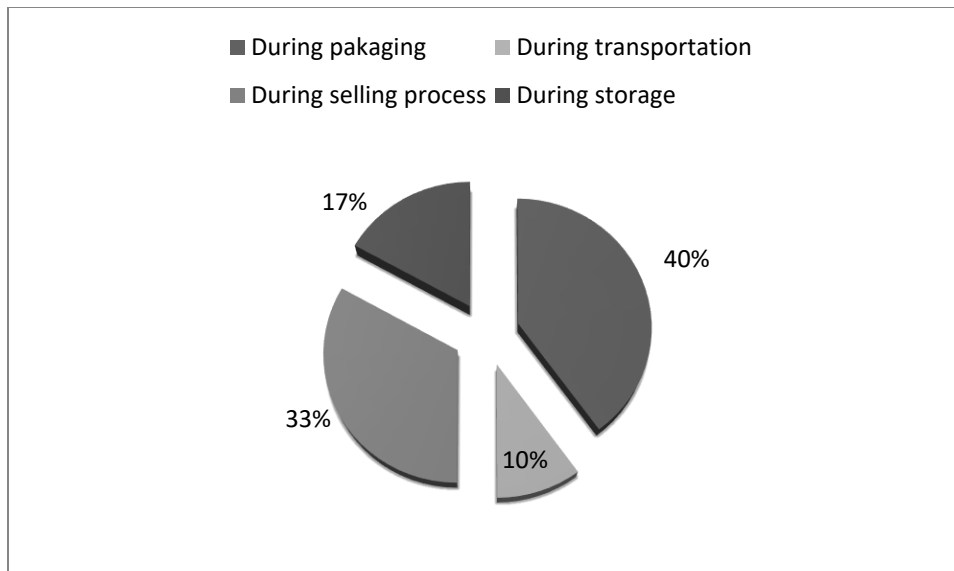


Figure: 3.13 Losses in the supermarket, Source: Bhandari survey in 2021-2022

The losses in the vegetable shops were relatively higher than that of the supermarket, the management system and supply chain structure were also found to be differentiating.

Out of the total loss of 7 percent in the vegetable shops, the following losses were generated in different types of vegetables.

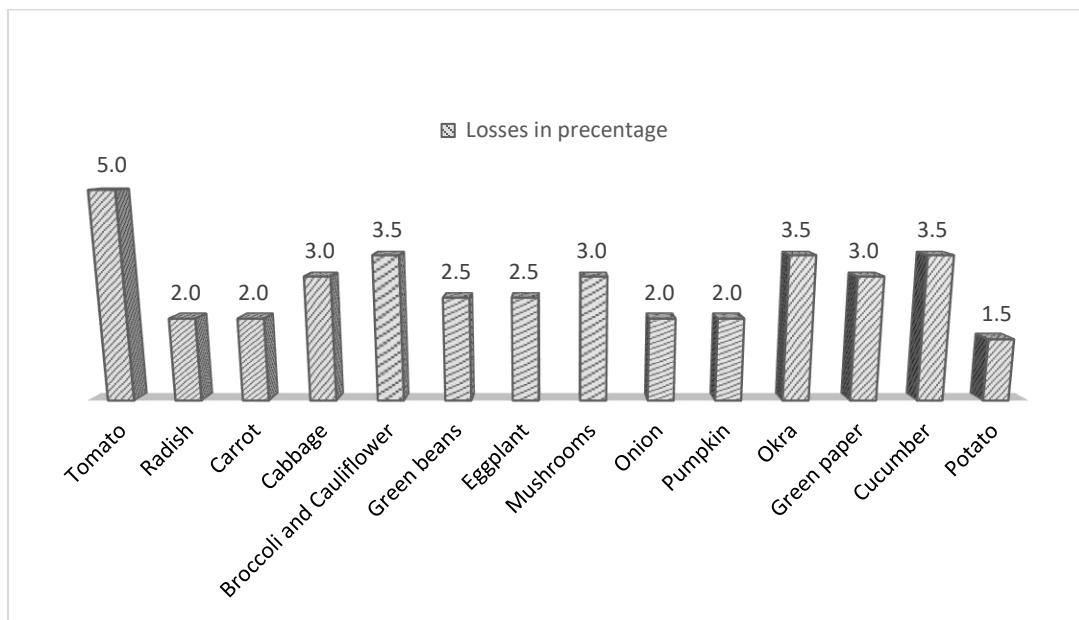


Figure: 3.14 Losses ratio of the vegetables in vegetable shops, Source: Bhandari survey in 2021-2022

Losses have occurred relatively high in the vegetable shops rather than supermarkets. Management systems, transportation vehicles, supply channels, vegetable quality, manpower, customer's behavior etc. are responsible for it.

As in the supermarkets, the vegetable shops were also found to be at a loss of vegetables at different stages. The losses incurred due to injuries caused by consumers while choosing vegetables were also high. In the case of vegetable shops, low quality packaging material has been found to be used comparatively with the supermarket.

Out of the total 7 percent losses, 35 Percent losses occurred during packaging, while selling processing was 31 percent, 19 percent during storage, and 15 percent during transportation.

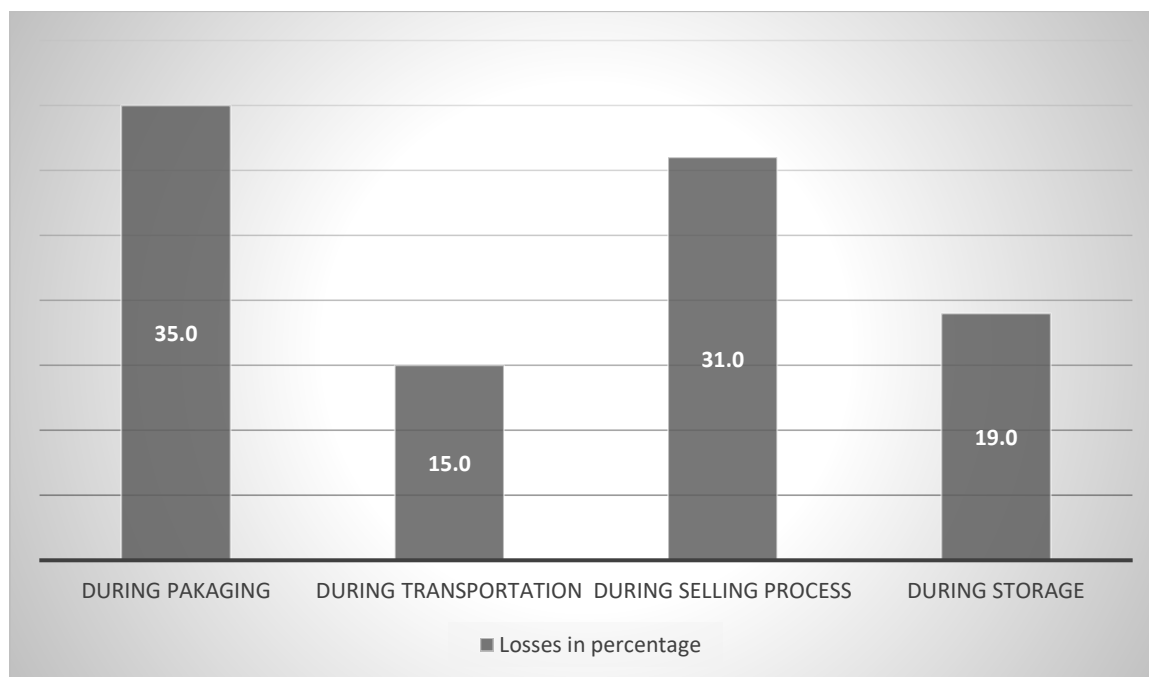


Figure: 3.15 Losses in vegetable shops, Source: Bhandari survey in 2021-2022

3.4 Result and discussion

3.4.1 Respondents profile

Age group of the respondents

The age of the farmer was divided into 5 groups. Which are, 30-40, 40-50, 50-60, 60-70 and above 70. The respondents of the age group 30-40 are only 6.0 percent of respondents engaged in vegetable farming. 9.5 percent in the 40-50 age group, 17.5 percent in the 50-60 age group, 36.0 percent in the 60-70 age group and 31 percent in the over 70 age group, were engaged in vegetable farming. Comparing the age group of respondents in Nepal and Japan, the age group between 40-50 was larger in Nepal, but in Japan, the age group between 50-60 was more than the other groups.

Gender of the respondents

It has been found that both men and women are involved in vegetable farming but in proportion 61.0 percent men and 39.0 percent women are involved. Among them, women are engaged in vegetable farming with their families. In the case of men, 12.0 percent were unmarried and the remaining 15.0 percent were divorced.

Respondents' literacy status

100 percent of the respondents were educated, among them 27.0 percent of the respondents are intermediate level, 15.0 percent are university level, rest of the others are graduates from other kinds of vocational school. The study showed that literacy plays a significant role in controlling postharvest losses, as all the respondents were aware of the losses and were making full efforts to manage them. In Nepal, farmers do not pay much attention to harvesting, preserving, packaging, and controlling losses during harvesting.

Income generation and production ratio of the respondents

35 percent of the respondents were cultivated in their own land, 40 percent were land taking in lease and the rest of 25 percent was using both, their own land as well as some land is taking for lease. 20 percent of the respondents are earning below 2,500,000 yen per year. 15 percent are

earning 2,500,000-30,000,000, 40 percent are 30, 000,000- 35,000,000, and the rest of the 25 percent respondents are earning above 35,000,000 yen annually. As there is a difference in the method of harvesting, there is also a difference in the income of the farmers in Japan and Nepal.

Frequency production

The respondents were producing 4 to 5 times in a year according to the types of the vegetables. Sometimes they produce more than two types of vegetables by using intercropping methods. It can be possible to produce more than twice the same cost and effort by intercropping. Nepali farmers in Nepal produce a maximum of three times a year, but in Japan, they cultivate vegetables 4 to 5 times. It is possible to implement such measures in Nepal as well.

3.4.2 Postharvest losses from farmer side

During harvesting

It is very difficult to measure exact losses during the harvesting period because it is different with the types of vegetables, if calculated on average approximately 2.5 percent of the losses occur during the harvesting time, said respondents. Even if pesticides are used to control diseases and insects, it cannot be completely prevented.

Losses during packaging

The deficit that occurs during packaging is about 1.0 percent. Portable plastics and carton boxes are common practice for packaging at farmer level. Farmers have to take the product to the collection center themselves. If the volume is high, it can be collected from the collection center, but farmers have to pay transportation charges for it. Vegetable packaging for the retailers is usually done by collection centers and wholesale distributors; they pack different sizes and volumes according to the market structure. The survey result is that in Nepal, the loss during packaging is the highest at 6 percent, which can be reduced by changing packaging materials and methods. Bags, crates, hampers, baskets, cartons, bulk bins, palletized containers, etc., are used as packaging material in Japan.

Losses during selection process

In Japan, product size and shape does really matter so farmers are really affected by this trend. Respondents said that losses arising during the selection process are up to 3.0 percent of the total production. According to the respondents the size cut products (unsightly) are usually used themselves or given to neighbors free of charge. In cases taken to the market, it doesn't even cover the production cost so farmers usually do not carry it to the collection center. In Nepal, the selection process is not given much attention. Other undamaged goods may also be damaged when packed with damaged goods, so the selection process on the farmer's side should apply in Nepal too.

Losses during loading and unloading process

Loading and unloading activities are the major cause of losses in the transportation process. About 1.0 percent losses occur during transportation. After the harvesting, cleaning and packaging process farmers have to take their production to the collection center. 95 percent of the farmers were using humans and 5 percent respondents were using lifting trucks during the loading unloading process. Total 7.5 percent losses were occurred in different sector at farmer side.

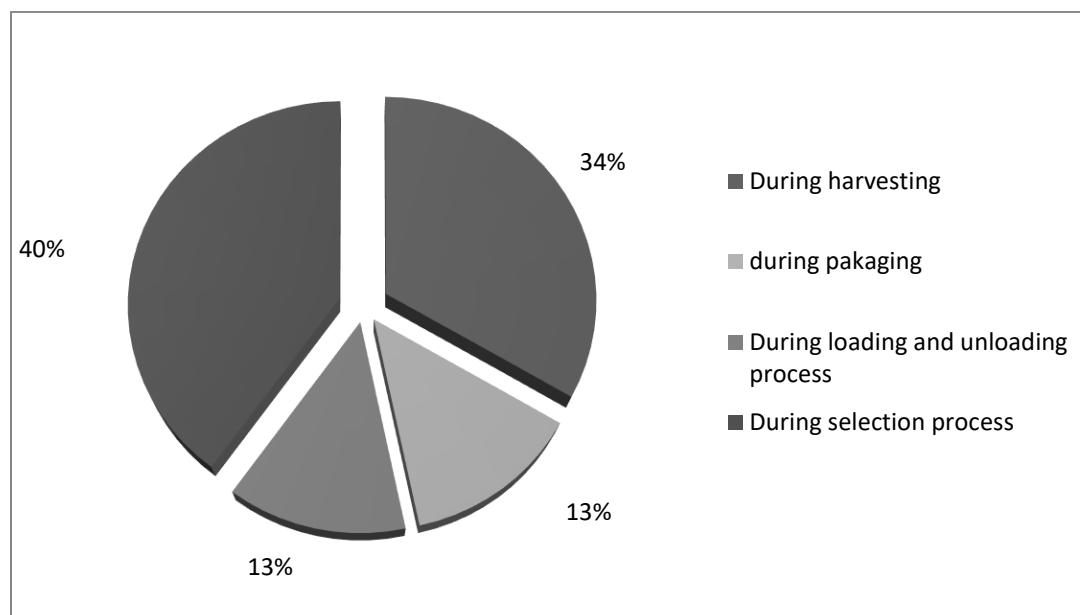


Figure: 3.16 Total postharvest losses from Farmers sides, Sources: Bhandari survey in 2021-2022

3.4.3 Vegetable losses in collection center

Including the JA collection and other collection centers, total 10 collection centers were conducted for the survey, which are in 4 Tokyo prefectures, 3 Saitama prefectures and 3 Kanagawa prefectures.

Despite the full cooling facilities and well managed storing system, during the packaging and placing movement losses had occurred 3.7 percent in Saitama prefecture, 3.5 percent in Kanagawa prefecture and 3.5 percent in Tokyo prefecture. Out of the total 3.5 percent in the collection center, 05 percent was during loading, 1.5 percent was during storage and another 1. 5 percent was during packaging. In other South Asian countries, the loss of vegetables is estimated to be around 5 percent,¹³⁷ but on the supplier side, it is 6.6 percent in Nepal, according to the survey.

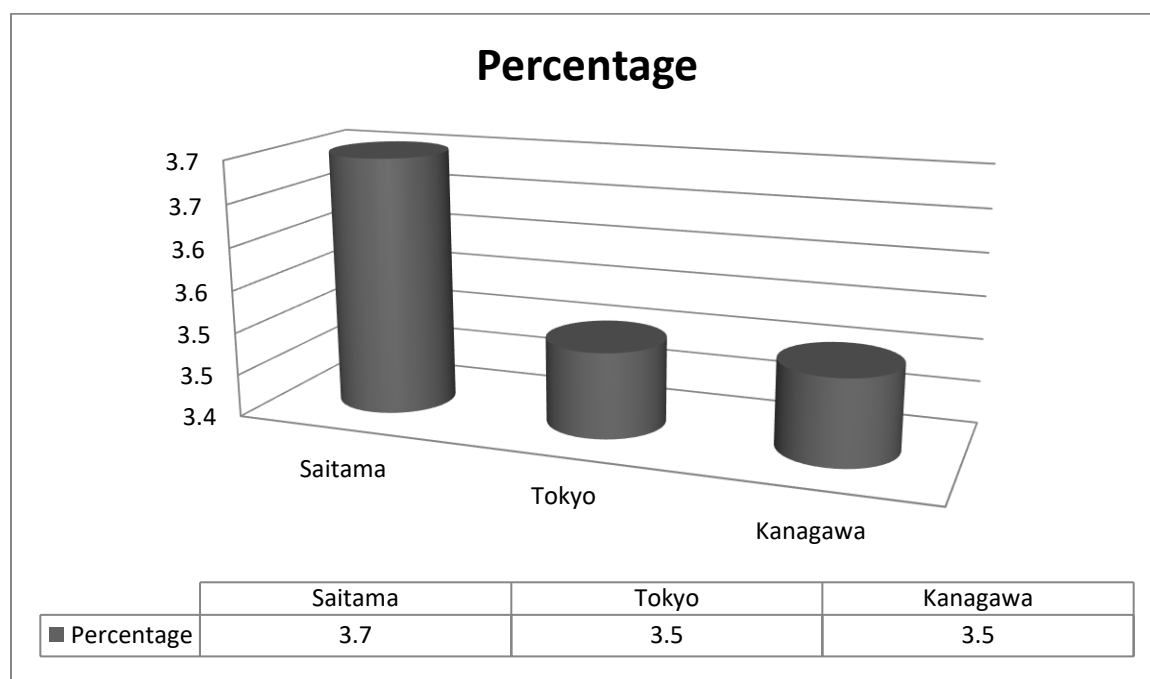


Figure: 3.17 Losses in collection center, Source: Bhandari survey in 2021-2022

¹³⁷Acedo et al. (2015). pp. 1-12.

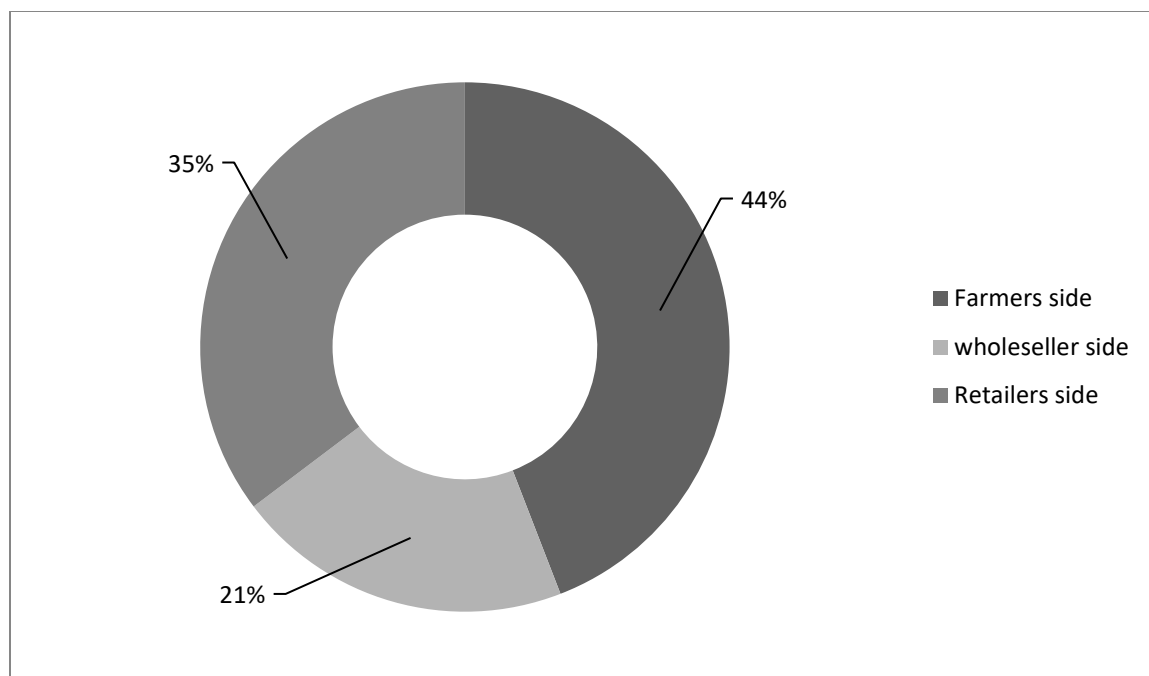


Figure: 3.18 Summary charts of the postharvest losses in different sectors, Source: Bhandari survey 2021-2022

3.5 Conclusion and summary

Every year Japan discards about 6.42 million tons of food, more than twice the world's total food aid of 3.2 million tons.¹³⁸ Where postharvest losses are also included, losses can reduce by controlling postharvest losses through after-harvest activities. Efforts to address such global food problems are needed to reduce food insecurity. It is difficult but necessary to work together to exchange information about the actual status of food losses and the efforts of relevant ministries and agencies under the liaison meeting of relevant ministries. Farmers, wholesalers, retailers, and consumers must work together to reduce food loss.

In this study, several aspects of the food wasted and food losses (including postharvest losses) have been included. We are very much aware that human life needs different kinds of nutrients to survive and we are provided those elements by different types of vegetables that we use in our daily life. But all of us may not be familiar with where those vegetables are farming, how those

¹³⁸Wenzel (2016).

are cultivated, what is the process of harvesting and supplying to the market, and how much cost and effort it takes to do all those processes. The answer to all those queries has been mentioned in this study. How did Japan come to the modern age of agriculture after going through so many stages? This issue also has been mentioned in the chapter. Studies confirm that despite the modernization of Japan's agricultural sector, many types of leaks still exist. This topic will help developing countries like Nepal to establish policies, harvesting methods, technologies, and supply chain systems to support them in the agricultural revolution.

This study was conducted with both a secondary data collection and primary data collection method, primary data was collected by questionnaires method with farmers, suppliers (wholesalers), and retailers and secondary data was collected with published and unpublished books and other internet sources. In the case of the primary data collection, 10 supermarkets, 5 vegetable shops, 8 collection centers (suppliers) and 25 farmers are included. In all these areas, the postharvest losses have occurred by different reasons in different stages. Out of the total 17 percent losses, the farmer side was 7.5 percent, 3.5 percent was at the supplier's side and 6 percent at the retailer side. All the respondents were educated and had complete knowledge about their profession, packaging material, harvesting time, area selection, cleaning, sorting and selection, the importance of cooling, etc. The survey found that those are all significant factors driving the deficit in Japan. Postharvest losses in Canada at the consumer and retail level are 23 percent,¹³⁹ much higher than in Japan. By practicing Japanese methods and technology, Nepal also controls postharvest losses.

Study was divided food waste in two parts; one is postharvest losses and another is food losses from other different sectors. The highest postharvest losses appeared in the farmer's side and retailer's sides. In the case of the farmers, they had to throw odd shaped or unsightly vegetables because of those postharvest losses at the farmer side is high otherwise farmers were found very sensible and full of awareness about their professions. If those odd products can be utilized in the functional food and as a raw material for the processing goods, farmers' side losses will be decreased by almost 50 percent. The concerned agencies and government should address these

¹³⁹Agriculture and Agri-Food Canada(2015).

kinds of problems. And consumers need to be aware that surface and approach alone cannot lead to healthy vegetables, it seems very important to give proper education in this regard from the school level.

Food is lost or discarded in the process of going through the food supply chain from agricultural produce to final household consumption. The results of the study suggest that public awareness is much more necessary to prevent food losses in different stages. As long as consumers do not have food consciousness, it is difficult for stakeholders to achieve concrete results no matter how much effort they give to control it. According to the survey, Japanese consumers still lack food awareness. For example, in Japan, there is an obligation to waste large quantities of odd size vegetables. If those vegetables can be used as a raw material for the processing goods, this will help to reduce the loss of vegetables to a great extent. In addition, by meeting the market demand by providing the vegetables which are currently used as raw material, a large amount of money can be saved which is used to purchase vegetables from foreign.

It is estimated that about 40 percent of food losses in developed countries occur at the retailer and consumer levels.¹⁴⁰ As noted by FAO, the case of Japan is almost the same. Consumers need to deepen their understanding that their consumption behavior can affect others in a wide range of areas such as environment, society and culture. Education for Sustainable Development (EDS) which contributes to the promotion of recycling, proper disposal and reduction of food wastage, as well as deepening the understanding of reconstruction of affected areas. It is very important to strive for dissemination and knowledge. Now is the time to look for good and beneficial uses for safe food. It is important to ensure transparency in consumer policy and to reflect consumer opinion. Support and promotion of voluntary efforts by consumer groups, businesses, business groups, etc.,

In developed countries, food is distributed downstream in the wholesale, retail and consumption phases of the supply chain. For example, Japan is throwing away large quantities of edible products due to the one-third rule, the convenience store's customer-first principle, and the trade-offs caused by oversupply.

¹⁴⁰Food and Agriculture Organization (2011).

In middle and high-income countries, a significant proportion of food is wasted at the consumption stage, which means that even if they are suitable for human consumption, they are still discarded. In low-income countries, food is often lost early or in the middle of the food supply chain, and very little is discarded at the consumer stage. The causes of food loss and wastage in low-income countries are mainly related to financial, operational and technical constraints on harvesting technology, storage and cold weather conditions, infrastructure, packaging and marketing systems. Lack of coordination between the food supply chain and consumer habits is a major cause of food loss and waste in middle- and high-income countries. Food waste can be reduced in industrialized countries by increasing the interest of the food industry.

In the developing countries, postharvest losses occur in the supply chain such as, harvesting, storage, transportation and processing stages. Developing countries lack knowledge, technology and funding for agriculture and the rationalization of agriculture is not as advanced as in developed countries. This led to the food losses incident and the loss of money that growers can get in return for their crops. The cooperation of developed countries is essential to improve it. It is necessary to transfer the knowledge and technology of highly productive agriculture, storage and processing methods that reduce the likelihood of producing food losses, and the equipment and technology to support its implementation. Special support is needed for pre-harvest agricultural measures, including "Fertilizer Management, Soil Addition, Water Management, Pest and Plague Management". Compared to postharvest measures, which are easier to implement and easier to understand, pre-harvest measures require a stable and basic approach to agriculture. Food losses are also happening due to inadequate infrastructure, and continuous support will be needed to improve it.

It is important to develop new technologies; including Agriculture intelligence (AI) and robotic technology to improve the productivity of facility horticulture and accelerate scale expansion. It is necessary to build agricultural houses which are not sufficiently weather resistant. In addition, it is necessary to formulate a damage prevention plan and implement measures such as strengthening agricultural practices.

To alleviate the plight of the starving people, the farmers of the developing countries must continue to harvest sufficient crops on their own. The food supply must be stable to stabilize the food supply. It is necessary to establish the habit of transporting the goods to the market by establishing portable power and transport networks. Since economically weaker developing countries do not have sufficient power to set their industries, the introduction of agricultural technologies used in developed countries will help in economic development by improving the country's infrastructure finally, in Japan people are bound by various food policy and laws. It seems that the result will be more positive if we will be able to make consumers aware about food loss rather than compel to follow law. This study concluded that education and harvesting activities significantly control crop losses. The root of loss starts at the farmer's level and his actions. Japanese farmers are very aware of pests and diseases in their fields and how to protect vegetables from them, harvesting materials, and what to do after harvesting. Even compared to other developing countries, postharvest losses are shallow in Japan. A study shows that in the United States, the loss of food at the farm level is about 12 percent, almost twice as much as in Japan.¹⁴¹

The study found that Japan has an excellently organized supply channel; farmers do not need to go through all the processes like packaging and cooling; JA group (wholesaler) does such activities. Still, in Nepal, there is no channel system. Hence, farmers need to know the importance of after-harvest processing and should practice which will help to reduce postharvest losses for the farmer, wholesaler, and retailers.

¹⁴¹Food and agricultural organization (2019).

Chapter 4 Postharvest losses of tomato in different supply chain in Nepal (97-131)

4. I Introduction

Nepal is an agricultural country where the majority of people 66 percent depend on agriculture for their livelihood.¹⁴² But this sector is not even commercialized, whereas the main thrust of the Agriculture Policy B.S 2061 is the commercialization of agriculture. The agriculture sector is the most critical in the Nepalese economy, which contributes about 26.7 percent of the country's total Gross Domestic Product (GDP).¹⁴³ The government has prioritized the agriculture sector and expended NRs. 41.4 billion in the F/Y 2020/21¹⁴⁴ which was 6.6 billion higher than the previous year.¹⁴⁵ Despite the priority given to the agricultural sector for many years, the country's rural poverty and backwardness have not changed significantly over the years. In the year 2016/17, the average economic growth was 3.4 percent, and the growth rate of the agriculture sector was only 2.7 percent.¹⁴⁶

Tomato (*Lycopersicon esculentum*, Mill) belongs to the family Solanaceae, one of the most universally known, widely consumable nutritious and widely grown vegetables globally. Its position in the whole world is after potato and sweet potato both in area and production. It can be eaten raw in salads or as an ingredient in many dishes and drinks. Tomatoes and tomato-based foods provide a wide variety of nutrients and many health-related benefits to the body. In regions where it is being cultivated and consumed, it constitutes an essential part of people's diet. These are available all the season in the market. The demand for tomatoes in the market and area under cultivation of the tomato increases day by day. Tomato being a high-value crop, either growing market demand and higher levels of return per hectare can help improve income for small landholders producing cereals with relatively low returns.¹⁴⁷

¹⁴²Central Bureau of Statistics Nepal (2017).pp.3-5. Approximately 66 percent of Nepali peoples are involved in the agricultural sector, although some other researchers cite different data.

¹⁴³Ministry of Agricultural Development (2019).

¹⁴⁴In Nepal fiscal year starts from the July ends to next June, 2020/21 means period between July 2020 to June 2021.

¹⁴⁵Ministry of Finance (2021). pp. 1-13. Budget for agriculture up by 6.6 billion in this year.

¹⁴⁶Central Bureau of Statistics (2017). pp. 9-17. This year has been increased due to a better-than-expected monsoon. According to the survey, Nepal's agricultural sector is currently projected to grow by 5.1 percent.

¹⁴⁷Shoaib, et al. (2012). pp. 89-90.

China, the USA, Italy, Turkey, India, and Egypt are the major tomato-growing countries. In 2019, the area under tomato in the world was 4.58 billion hectares (ha), with a production of 38.5 million tons and a productivity of 38.8 tons/ha. In the same year, the area under tomato in China was 10.03 million ha, with 5.64 billion tons and 56.5 tons/ha productivity. In 2019, the area under tomato in India was 7.6 million ha, with a production of 1.83 billion tons and a productivity of 25.5 tons/ha. In the year 2019 total area and production of tomato in Nepal was estimated at 17,300 ha and 2.6 million tons, respectively, with average productivity of 15.02 tons/ ha, which is very low compared to the productivity of the existing hybrid varieties.¹⁴⁸

Postharvest management comprises the various technologies and practices undergone by the farmer, farmers' groups or cooperatives, and agribusiness companies, from the field to the plate, to handle the crop production immediately following harvest, up to its final destination, such as storing, transport, cleaning, sorting, processing, and packing. Postharvest management aims to maximize this added value. Harvesting and postharvest management of tomatoes were widely used; hence pink or soft ripe fruits were normally found ideal for harvesting depending on the market requirement, i.e., cherry ripe for processing, fully ripe, firm, for hotels and fast-food outlets, pink to ripe for greengrocers and supermarket, and mature and green for extended shelf life. Depending on the variety, Tomato is ready for harvesting 73 - 75 days from planting. Tomatoes should be reaped with calyx intact. Field containers should be light colored ventilated field crates¹⁴⁹ are ideal, with a carrying capacity of 35 lbs., i.e., 2 - 3 layers of fruits interpacket with shredded paper, so as to prevent squeezing (compression) damage. Light colored water buckets can also be used to remove fruits from field to pack house. Light-colored plastic ventilated crates are preferred for packaging; Crates should not be over-packed but should have adequate space at the top, allowing proper vehicle storage. Retail packaging in 0.4 - 1 kg plastic containers is desirable and should be stored in display refrigerators of 13 - 15°C or 50 - 55°F. Refrigerated trucks are preferred during transportation, but an opened body truck covered with a light-colored tarp can be used where this is not available. The vehicle should have enough space to provide proper storage and adequate ventilation. Tomato can be stored at ambient temperature

¹⁴⁸Please check the site of Vegetable Development Directorate (2020). According to the sources Nepal's yield ratio is much lower than with China and India.

¹⁴⁹Crate is a plastic bucket that is used to carry vegetables. One crate holds about 20 kg.

for up to 7 days. For a more extended period, tomatoes can be stored at a temperature of 13 - 15°C or 50 - 55°F and relative humidity of 80 - 85 percent.¹⁵⁰

Tomatoes' postharvest losses can be as high as 25 - 42 percent globally.¹⁵¹ These losses bring low returns to growers, processors, and traders as well as the whole country which suffers in terms of foreign exchange earnings. Vegetable postharvest losses vary considerably, with maximum average losses of up to 50 percent or higher occurring in developing countries.¹⁵²

Tomato's postharvest losses are due to the value chain activities during handling and storage, processing and packaging, distribution and marketing, and till consumption. There are many kinds of losses during value chain activities due to pathologically and entomologically damaged, physiologically damaged, inappropriate handling technology, inappropriate storage facilities, inappropriate mode of transportation, and other damage. Physical handling can drastically affect the postharvest quality or life of harvested fruits. Rough handling during and after harvesting can result in mechanical injuries, affecting quality. Tomatoes are harvested by manual picking in most developing countries instead of robotic picking.¹⁵³

A supply chain includes more than one company in supplier-customer relationships. A supply chain in the context of agro-products, particularly related to the tomato, would embrace all activities starting from seed suppliers to the end consumer. Postharvest losses during the supply chain include farm gate after harvest to consumer losses. The supply chain of tomatoes in Nepal is still a big challenge. For local markets use of tractors and vans is a common practice.¹⁵⁴

The Kavrepalanchok district has a high potential for tomato production. According to the Annual progress report of the district agriculture development office, Kavrepalanchok, approximately 27,500 tons of tomatoes were harvested from 2,736 hectares of land in 2018. Farmers are planning to promote the production of tomato sauce, ketchup, and pickles under the program. Primary reasons for the lower yield are the dominance of rain-fed agriculture, lack of assured

¹⁵⁰Kader, et al. (2004). pp. 1279-1282.

¹⁵¹Kader, *ibid.* (2004). study shows that postharvest losses rate of developing countries is higher than that of developed countries.

¹⁵²Hodges, et al. (2011). Postharvest losses and waste in developed and less developed countries: opportunities to improve resource use. pp.37-45.

¹⁵³Arah, I. (2015). pp. 21-32. As the author said, it is the same situation in Nepal.

¹⁵⁴Kaini, B.R. (2000). pp.211-218. According to my survey, the situation has not changed so far.

supply of hybrid seeds, problems in the timely availability of chemical fertilizers and agrochemicals, partly associated with the pre-harvest practices and partly with the lack of appropriate postharvest techniques. The pre-harvest issues include a low level of management, use of local cultivars, diseases and pests' occurrences, and other physiological disorders. Keeping this point of view, postharvest losses in the supply chain of tomato was carried out in the selected district.

4.1.1 Statement of problem

Tomato is one of the most popular vegetables in Nepal; its commercial production increases due to higher return on investment, particularly in the off-season. However, sometimes on the part of tomatoes, farmers had bitter experiences of meager prices of tomatoes even not getting the cost of tomato harvesting. Price fluctuation is very common in tomato marketing in Nepal. The planting and nutritional requirements of tomato production have been widely investigated and documented.

The weakness and strengths of tomato production and postharvest activities at the national level have been found spelled out. Still, the issue at the municipality level has not been studied in an absolute sense. This study was designed to address the following question to explore the exact situation of postharvest aspects of the study area. What is the situation of postharvest losses of tomatoes? What was the problem faced by farmers? Where is the main leakage in the supply chain system? Therefore, the following study has been undertaken with the following rationale and objectives.

4.1.2 Justification of the study

Despite the great potential of crop farming in Nepal, a substantial crop is imported every year. The livelihood of over three-quarters of all Nepalese is based on agriculture, and about 66 percent of the population is directly involved in the agricultural sector.

Postharvest technology is inter-disciplinary “science and technique” applied to agricultural produce after harvest for its production, conservation, processing, packaging, distribution, marketing, and utilization to meet the food and nutritional requirements of the people about their needs.

Preventing postharvest losses can save thousands of tons of fruits and vegetables. It is more economical to reduce losses than to increase production. In comparison, it is easier to minimize losses than to increase yields. Thus, the supply of fruits and vegetables can be increased dramatically without bringing additional land inputs for the production.¹⁵⁵

There is no more research on postharvest losses of tomatoes in the supply chain system in the study area, and there is a huge gap between research and policy formulation. In most cases, farmers are unaware of postharvest technology; hence, they suffer postharvest losses in tomatoes and do not get reasonable prices for their products. Similarly, farmers are unaware of adopting new technology due to insufficient trained human resources and lack of institutional development in the concerned field. The district agriculture Development office of Kavrepalanchok has not detailed the postharvest losses scenario of tomatoes at the municipality level. Therefore, this study was undertaken to provide the status of postharvest losses under the study area. The finding will help adopt new postharvest handling practices to minimize the postharvest losses and increase the farm income/yield.

4.1.3 Objectives

The study's overall objective was to examine the postharvest losses of tomatoes in the Kavrepalanchok district during the supply chain system. To find out the gaps between improved postharvest practices and the practices followed by different actors at different levels of the tomato supply chain of tomato.

4.1.4 Scope of the study

Despite the farmers' extensive coverage of farming land, they are not generating actual profits due to the several losses in the supply chain of production to market linkage. This is due to the lack of postharvest management techniques for the long-term storage of fruits and vegetables. Under proper handling of postharvest losses that occur in picking, packaging, transporting, retailing, etc., ample output can be increased.

¹⁵⁵Bhattarai, et al. (2009). pp. 37-40. Nepali farmers have very poor knowledge about their profession. They are not aware that can control the postharvest losses accepting by new concept and methods of harvesting.

The study was confined to the Dhulikhel Municipality, Banepa Municipality, Panauti Municipality, Panchkhal Municipality, Namobuddha Municipality, and Mandandeupur Municipality Kavrepalanchok district, mainly concentrating on the postharvest harvest losses of tomato during the supply chain system. This study helps the concerned agency identify the need and problems farmers, suppliers, and retailers face in postharvest losses. This study helps get information regarding tomato growers, suppliers, and retailers and is helpful for GONs, NGOs, INGOs, researchers, students, policymakers, and related stakeholders working in horticulture.

4.1.5 Limitation of the study

The number of farmers, suppliers (wholesalers), and retailers interviewed in the study represents a small sample of the total numbers. Thus, valid statistical generalization based on this limitation data cannot be made. This study is only conducted in the Kavrepalanchok district, so the finding may not justify the overall scenario of Nepal and does not cover all the aspects of tomato growers. Information presented in this study is based on the response of tomato grower farmers, wholesalers, and retailers, so memory recall bias is inevitable. Students as researchers have limited time and budget to investigate all the aspects of a large population. Also, in this pandemic time, people are hesitant to face interviews.

4.2 Literature review

In this chapter, an attempt is made to review the workout at a loss after a harvest of tomatoes. There is little information about postharvest losses along the tomato supply chain. Efforts have been made to review recent literature under the various subheadings in the current study. Related literature is briefly reviewed under the following headings and subheadings.

4.2.1 Tomato production in Nepal

Nepal is an agricultural country; most people are involved in the agriculture sector. Tomato production has been the primary occupation for the livelihood in our country. It is grown seasonal as well as off-season. The production of tomatoes increases day to day as per the market demand. The production of tomatoes in eastern hills in 2018/19 was 2,874.5 ha, with 64,860.6 metric tons (MT) and a yield of 22.5 MT/ha. The production of tomatoes in eastern Terai in 2018/19 was 2300 ha, with the production of 40,423 MT and 17.6 MT/ha. Overall, the east

region was 5,419.5 ha with the production of 108,703.6 MT, and the yield was 20.05 MT/ha. The production of tomatoes in the central region was 8,293.9 ha, with the production of 134,597.5 MT, and the yield was 16.22 MT/ha. The production of tomatoes in the western part was 2,764.6 ha, with the production of 48,856.3 MT, and the yield was 19.1 MT/ha. Similarly, the production of tomatoes in the mid–western region was 2,613.5 ha, with the production of 34,505.7 MT, and the yield was 13.20 MT/ha. And also, the production of tomatoes in the far–western region was in the area of 1436.4 ha, with the production of 20,410.6 MT and the yield of 14.2 MT/ ha. In the whole of Nepal, the production of tomatoes was in 21046 ha area; the production was 355,045.2 MT, and the yield was 16.8 MT/ha.¹⁵⁶

Tomatoes are grown as an annual plant all over the world and also in Nepal. It has rich sources of minerals, vitamins, and organic acids. Tomato is a perfect appetizer known as “poor man’s orange.” The tomato is an herbaceous annual plant with a bisexual flower. The fruit is a true berry and self-pollinated. Tomatoes have been categorized into determinate and indeterminate depending on growth habits. The optimum temperature is 21 - 25°C. Tomato is neither frost tolerant nor water logged condition tolerant. The soil must be well-drained, fertile, and rich in organic matter with appropriate moisture content. The tomato can be grown throughout the year.

Table No. 4.1 Schedule of tomato cultivation in Nepal

Area	Season	Time of nursery sowing	Transplanting
Plains	Autumn / Winter Late	January, July- August	February, August-September
Frost free areas	Autumn		
Hills	Spring /Summer	Late November	January
	Spring / Summer	March - April	April - May

Source: Central Bureau of Statistics, Nepal

However, the number of crops and time of seed sowing directly depends upon the climatic condition of the region.

¹⁵⁶Forum for Rural Welfare and Agricultural Reform for Development (2016).

The production of tomatoes is generally done by the seedlings raised in the nursery. Generally, tomato production is done in Nepal's open space and greenhouse tunnels. Tomatoes can be grown in open spaces, but yields are lower than tomatoes grown in greenhouses or tunnels. Protected cultivation is feasible for the production of tomatoes in large amounts. Cultivating tomatoes in the greenhouse would help obtain high productivity and better return. Tomatoes grown in protected greenhouses have comparatively more yield per hectare than the open field space. There is also less chance of getting the disease in the greenhouse. It may be reported that about 40 - 45 percent higher marketable yield will be in the greenhouse than with open field conditions. The plant grown under the greenhouse will thrive compared to the open field space.

4.2.2 Postharvest losses of tomato in Nepal

The study analyzed that about a quarter of the total tomato production losses occur before reaching consumers. Price chain artists trade another one-fifth at a lower price due to quality loss. Loss after harvest (weight and quality loss) is not the same for all price chain participants; the average monetary deficit is up to 4 percent of farmers' total income and 12 percent of wholesalers.¹⁵⁷

According to Khadka, up to 50 percent of postharvest losses of tomatoes arise from Terai of Nepal. Postharvest losses are primarily associated with microbial contamination that promotes spoilage during transportation, storage, and marketing. These microorganisms can contaminate tomato fruits both before and after harvest.¹⁵⁸

According to Bhattarai and Gautam, the physiological weight loss of tomatoes after ten days of storage ranged from 15.07 to 15.27 percent. On the other hand, calcium chloride treatment significantly affected the physiological weight loss of tomatoes immediately and after the second

¹⁵⁷Gautama, et al. (2017). pp. 2547-2558. Writer said that the postharvest loss on the wholesaler side is much higher than on the farmer and retailer side. Which does not match with my survey where losses on the farmer side are higher than the wholesaler and retailer.

¹⁵⁸Khadka, et al. (2017). pp. 1-7. According to the writer, the postharvest loss is higher in the Terai area than in my research site.

day of harvest. In general practice in Nepal, it takes about 5 to 20 days to reach the level from farm to consumer.¹⁵⁹

The study found that many of the decisions made during crop production can significantly impact the quality of postharvest losses. It was important to remember that product quality was maintained only after harvest and did not improve during the harvest and storage process. Therefore, it was of utmost importance to consider the pre-harvest factors that allowed us to maximize the quality of the vegetables stored. These factors included production and management decisions regarding soil fertility, variety selection, irrigation, and pest management.

Postharvest handling in the country accounts for about 40 to 44 percent. These vast losses were mainly due to inadequate infrastructure and postharvest processing techniques. Not aware of improper use of harvesting tools, harvest time (mature or immature), lack of refrigeration and packaging facilities, etc.¹⁶⁰

According to Tiwari, postharvest losses in Nepal are higher at retailer sites, with 10 percent of postharvest losses found in the market. And farmers are aware of their production losses. Producers have played an essential role in reducing the postharvest loss of tomatoes, so public awareness about the proper harvesting and storage of tomatoes should be raised through mass media.¹⁶¹

4.2.3 Postharvest losses of tomato worldwide

Tomato is one of the highly perishable crops among the vegetables. Primary factors responsible for postharvest production losses include poor pre-harvest measures, adoption of poor production techniques (varieties with low shelf life, imbalance use of nutrients, insect pest and disease infestation, and abiotic stresses), non-application of pre-harvest recommended treatments/practices, harvesting at the improper stage and improper care at harvest; and postharvest problems, non-removal of field heat, dumping produce, moisture condensation

¹⁵⁹Bhattarai, *ibid.* (2009). pp. 37-40. Due to the poor market channel and political strikes, sometimes products must be stored on-field or transport vehicles at that moment, so postharvest losses occur more than expected.

¹⁶⁰Adhikari, et al. (2021). pp. 227-233. I agree with the author's conclusion.

¹⁶¹Tiwari, et al. (2020). On this topic, I'm afraid I have to disagree with the writers because I found that on the research site, farmers are not aware of harvesting methods and technology and the reason behind the postharvest losses.

causing pathogen infestation, packaging in bulk without sorting and grading of produce, improper transportation and storage, and distant and time-consuming market distribution. These losses bring a low return to growers, processors, and traders, and the country also suffers in foreign exchange earnings.¹⁶²

Tomatoes' postharvest losses can be as high as 25 - 42 percent globally.¹⁶³ These losses bring low returns to growers, processors, traders, and the whole country, which suffers in terms of foreign exchange earnings. In the Nepal terai districts of Kapilvastu and Banke, postharvest losses of tomatoes were estimated at 25 percent.¹⁶⁴

Evidence suggests that these losses tend to be the highest in those countries where the need for food is greater. Which provides loss figures of 15 - 50 percent in more minor industrialized counties; half of what is produced never reaches the consumer for whom it was grown, and the effort and money required to produce it are lost forever. Reduction in postharvest losses, particularly if it can economically be avoided, would greatly benefit growers and consumers alike.¹⁶⁵

It is believed that postharvest losses are higher in more minor industrialized counties; this generalization may not be accurate, and higher losses may occur in developing countries for lack of suitable facilities and technologies. However, these losses may be lower in less urbanized regions. The products need to be transported a shorter distance to market, and there is a shorter time lag between harvesting and consumption. On the other hand, in industrialized countries, produce is shipped for longer distances, and the marketing system is more complicated. These factors contribute to more significant postharvest losses, which better facilities and technologies may not fully compensate.¹⁶⁶

It is safe to say that postharvest losses occur in every country. Still, the magnitude and major causes of losses and the effective remedial methods differ significantly from one country to

¹⁶²Kader, A. A. (2013). pp. 1-8.

¹⁶³Rehman, et al.(2007). pp. 1279-1284.

¹⁶⁴Source, Agribusiness Promotion and Statistics Division (2011).

¹⁶⁵Zaldivar, C. P. (1991). pp. 205-209. This research was done about 30 years ago but so far, the situation in Nepal is as the author says.

¹⁶⁶Bourne, M. C. (2006). pp. 43-46. According to other researchers, postharvest losses in the supply chain are much higher in developing or third-world countries. Still, food losses in kitchens and restaurants are much higher in developed countries.

another, one season, or even one day to another. Therefore, any published figures vary rapidly enough that their usefulness is short-lived and is no more than estimated.¹⁶⁷

Postharvest losses in tomatoes can be either quantitative or qualitative. Even though the emphasis on crop research nowadays is increasingly shifting from quantity to quality of products, there is still slight improvement in the quality of commercially produced tomato varieties, hence resulting in a high number of qualitative losses. However, qualitative loss in tomato production can harm many parameters like consumer acceptability, nutrient status of fruits, and financial income to producers. Therefore, an investigation into the possible factors that can affect the postharvest quality of tomatoes is necessary.¹⁶⁸

The postharvest qualities of tomatoes are dependent not only on postharvest handling and treatment methods but also on many pre-harvest factors such as genetic and environmental conditions. Many cultural practices such as types of nutrients, water supply, and harvesting methods are also believed to influence both pre-and postharvest quality of tomatoes. Many postharvest quality losses are a result of many pre-harvest factors. Before harvesting, tomatoes that are diseased and infected by pests, inappropriately irrigated and fertilized, or generally of poor quality can never be improved by any postharvest treatment methods.¹⁶⁹

A downgrade in quality leads to a loss of consumer appeal. It is frequently described by comparison with locally accepted standards for premium quality such as appearance, taste, texture, and nutritional value.¹⁷⁰ There is revenue lost from both quantitative and qualitative losses. The cost of postharvest losses cuts across the entire food supply chain and negates the potential profits of every actor involved in the vegetable handling and marketing system. The economic losses also influence the marketing prices of each commodity. Accordingly, products with higher postharvest losses often fetch higher prices. Qualitative losses are much more challenging to assess than quantitative losses. Losses in quality are evidenced by a decrease in the market value of the product.

¹⁶⁷Raja, et al. (1993). pp. 265-277.

¹⁶⁸Beckles, D.M. (2012). pp. 129-140.

¹⁶⁹See, Arah, et al.(2015). pp. 1-4.

¹⁷⁰Ladaniya, M.S.(2008). pp. 67-69.

The fruit cracking and blossom end rot are among the soil moisture-related physiological disorders that causality and yield losses in tomato production. For instance, in America, tomato yield losses due to fruit cracking reach up to 35 percent in some areas¹⁷¹

High postharvest losses are caused by fungi, bacteria, insects, and other organisms' invasion. Microorganisms attack fresh produce easily and spread quickly because the product doesn't have much of natural defense mechanisms and has plenty of nutrients and moisture to support microbial growth. Postharvest rot prevention is becoming a more difficult task as the number of pesticides declines rapidly as the safety of consumer concerns increases. The estimated loss of fruits and vegetables is about 30 percent by diseases only in tropical countries.

The ripening stages of tomato fruits include immature, mature green, breaker, pink and red. In Nepal, there are no standard maturity indices available; hence harvesting a tomato depends on the experiences and judgments of the farmers. The maturity stage at which tomato fruits are harvested depends on the prevailing weather conditions, consumer preferences, and market distance. The harvesting operation may influence the postharvest storability of the fruit. The fruits are removed from the plants by gently twisting them without tearing or causing due damage to the plant's fruit. However, not all farmers or field workers pay this as necessary attention.

Most growers, however, wash their fruits sufficiently to remove dust and other foreign materials by rinsing the tomato in clean water. In Nepal, grading is usually not done if tomatoes are to be sent to the local markets. For supermarkets, the fruits are graded manually into different sizes, shapes, and colors and packed in trays, cardboard, or wooden boxes of not more than 15 - 20 kg per box.¹⁷²

4.2.4 Postharvest loss of tomato in different activities of value chain

The physiological maturity of the fruit at the harvesting stage has a significant effect on quality; therefore, care must be taken as to when to harvest the fruit to attain the best quality. Postharvest physiologists describe three stages in the life span of fruits and vegetables: maturation, ripening,

¹⁷¹Heine, et al.(2009). p.146.

¹⁷²See, Agricultural Extension in South Asia(2021). pp. 228-231.

and senescence. The growth is indicative of the fruit being ready for harvest, and there are three maturity states at which tomatoes can be harvested. It can be harvested either in matured green, partially ripened, or ripened state. Tomato being a climacteric fruit can be harvested at the matured green state, allowing ripening and senescence to occur during the postharvest period of the fruit.

Farmers targeting distant markets must harvest their tomatoes in a matured green state. This will give the producers ample time to prepare the fruit for the market and prevent mechanical injuries during harvesting. Fully ripened tomatoes are susceptible to injuries during harvesting, resulting in shorter shelf life.¹⁷³

Physical handling can drastically affect the postharvest quality or life of harvested tomatoes. Rough handling during and after harvesting can result in mechanical injuries that affect quality. Typical industrial production systems associated with tomatoes may include mechanical harvesting, packing into crates, sorting, grading, washing, and transporting over long distances. At each stage, there may be a significant occurrence of mechanical injury which may be bruising, scarring, scuffing, cutting, or puncturing the fruits. In small-scale tomato production, mechanical injuries may result from inappropriate harvesting containers and packaging materials.

The effects of mechanical injuries on fruit are cumulative. Injuries that are equivalent to or greater than the bio yield point led to a total breakdown of the structure of the affected cells, which is accompanied by unwanted metabolic activities, which may include increased ethylene production, accelerated respiration rates, and which results in either reduced shelf life or poor quality. Therefore, it is essential to handle tomato fruit with care during the harvest and postharvest activities to minimize mechanical injuries to avoid losses.¹⁷⁴

In most developing countries, tomatoes are harvested by manual picking instead of mechanical picking. In harvesting, care should be taken to avoid mechanical damage, an entry point for disease-causing pathogens. Overloading during harvesting can cause a buildup of excessive compressive stresses resulting in the crushing of fruits found at the base of the containers. The

¹⁷³Toivonen, P. M. (2007) . pp. 1-5.

¹⁷⁴Miller, et al. (2003). pp. 9-14.

use of smooth surfaces and shallow containers to prevent overloading will reduce mechanical injuries and the crushing of the harvested fruits. Therefore, it has recommended the use of plastic baskets for harvesting tomatoes.¹⁷⁵

90 percent of farmers have no on-farm storage facilities and therefore leave their harvested produce at the mercy of the weather. This can result in excessive moisture loss and subsequent deterioration of the crop. Adopting a simple on-farm structure like a small hut or poly net for temporal storage of harvested produce can be very beneficial in pre-cooling (the first step in good temperature management).¹⁷⁶

The total loss during the transportation of tomatoes from Syangja (mid-hills) to Butwal (markets in the plains) was around 23 percent. Similarly, the losses sustained during transportation of tomatoes up to Kathmandu from Kapurkot, Salyan (western hills), and Lalbandi, Sarlahi (Terai) were approximately 35 percent. Physical losses, which occur during the transportation of tomato, from Kapurkot, Salyan, Nepal to Sitapur market Lucknow, India, were 10 percent ¹⁷⁷ similarly physical losses in tomatoes from Kapurkot, Salyan, Nepal to Azadpur market, New Delhi, India were 1.33 percent. Similarly, the mechanical loss during transportation of tomato up to Kathmandu from Kapurkot, Salyan (mid hills) and Lalbandi (Terai) were found 35 percent.¹⁷⁸

In developing countries like Nigeria, storage, packaging, transport, and handling techniques are practically non-existent with perishable crops, allowing for considerable losses of produce. Thus, as more fresh fruits are needed to supply the growing population in developing countries, as more produce is transported to non-producing areas, and more commodities are stored longer to obtain a year-round supply, postharvest loss prevention technology measures become paramount. Postharvest losses have been highlighted as one of the determinants of the food problem in most developing countries like Nigeria.¹⁷⁹

The majority of the production fields are located in remote areas, far from improved roads making access to competitive markets difficult and costly. In cases where roads link these

¹⁷⁵See, Arah, et al.(2015). pp. 1-5.

¹⁷⁶Bachmann, et al. (2000). pp. 3-14.

¹⁷⁷Food and Agriculture Organization (2006). pp. 45-57.

¹⁷⁸Kaini, B.R.(2000). pp.211-218.

¹⁷⁹Babalola, et al. (2010). pp. 14-18.

farming sites, these roads are in a very deplorable condition. The bad state of road infrastructure makes it very difficult, expensive, and time-consuming to transport harvested tomatoes to the marketing centers. Meanwhile, any delay between harvest and consumption of the tomatoes can result in losses.

Farmers incur losses of up to about 20 percent due to transportation delays. This claim may even be an underestimation of the actual transportation losses as vehicles that play these deplorable roads sometimes get stuck in the mud and may take hours or even days to get them out, resulting in losses higher than the 20 percent assertion.¹⁸⁰

The unavailability of processing factories or redundancy in the available ones is another challenge tomato producer in developing countries face. Senegal promoted tomato farming and established processing plants that made Senegal the 23rd largest processor in the world during the early 1970s. Produce from farmers was used as the raw materials for these processing industries.¹⁸¹

4.3Material and methods

4.3.1 Descriptions of the study area

The present study of "Postharvest losses of tomato in different supply chain systems" was carried out in the different municipalities of the Kavrepalanchowk district. Kavrepalanchok district is 21 kilometers east of the country's capital, while Dhulikhel, the district headquarters, is 31 kilometers away. The district covers an area of 1404 sq km between 85024 'to 85049' east longitude and 27021 'to 27085' north latitude. It is bounded east by Ramechhap district and Dolakha district, on the west by Kathmandu, Lalitpur, and Bhaktapur district, on the north by Sindhupalchowk district, on the south by Sindhupalchowk, Sindhuli and Makwanpur district. Surrounded by Sunkoshi in the east, Nagarkot Dada (high hill) and Sanga Bhanjyang in the west, Indravati and Sunkoshi Rivers in the north, and Kokhajor and Khani rivers in the south, Kavrepalanchok district is considered to be a district of geographical heterogeneity and natural resources. From an altitude of 318 m above sea level (Kokhajor river) to 3018 m (Vethanchok

¹⁸⁰Babatola, et al.(2008). pp. 490-493.

¹⁸¹Prusky, D. (2011). pp.463-474.

Narayan hill), most of the district is covered with hilly terrain. It has 76 Village Development Committees (VDCs) and five municipalities, including two newly organized, i.e., Panchkhal and kashikhanda. It has the huge potentialities of local tourism with the various geographic natures and cultural heritages. The primary profession of the residents in the kavrepalanchowk district is agriculture. The district is divided into 15 development clusters (Ilaka), and agricultural land is about 37,405 hectares.¹⁸²

Survey sites

The survey was conducted in various municipalities of the Kavrepalanchok district, but farmers of the Pachahal, Dhulikhel, and Panauti municipalities were relatively more involved in tomato farming.

¹⁸²Japan International Cooperation Agency (2016). pp. 3-17.

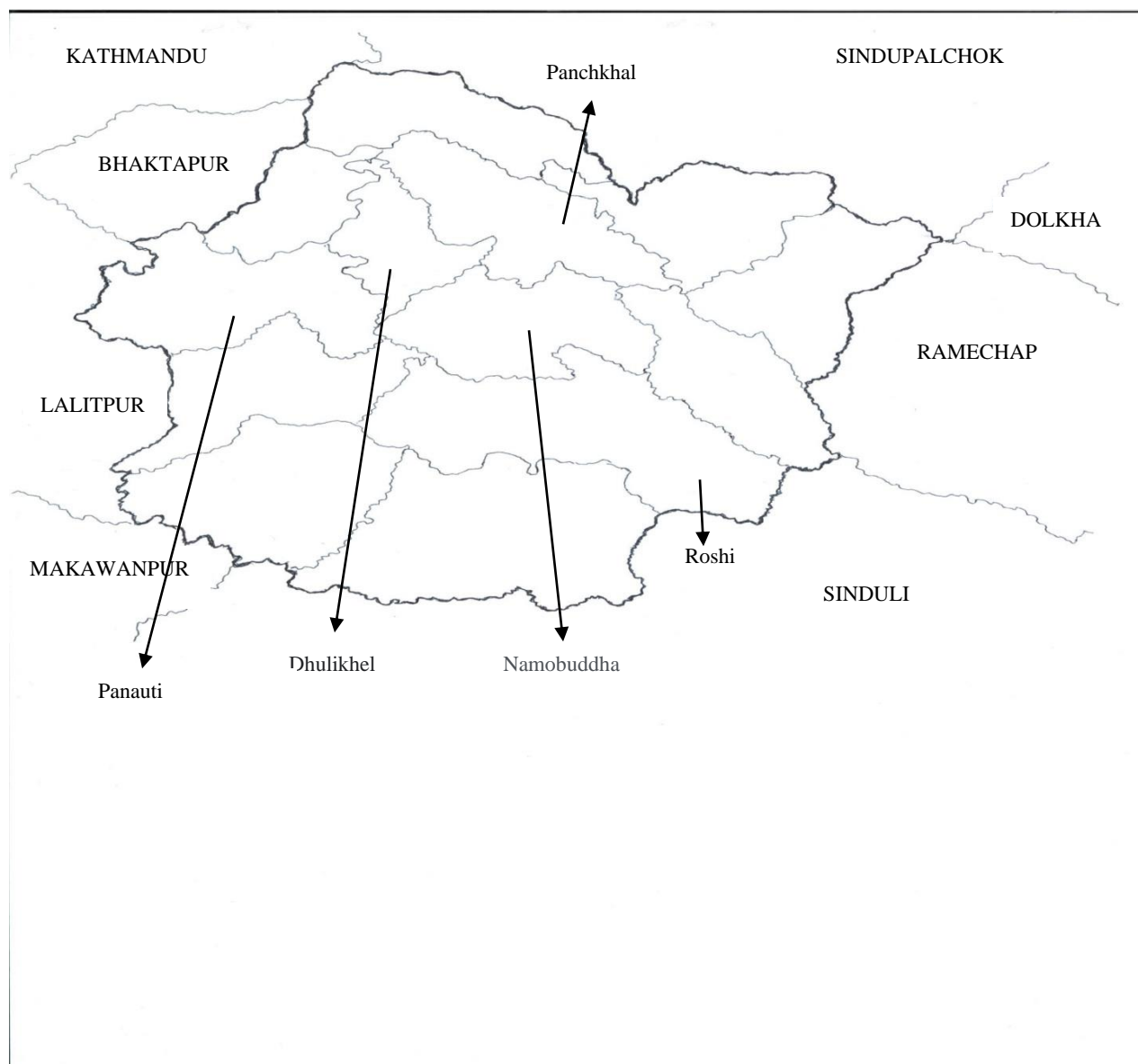


Figure: 4.1 survey site Kavrepalanchok district, Source: Handmade map

4.3.2 Duration of the study

The questionnaire survey was conducted for 40 days, from 28th April to 17th May of 2020.

4.3.3 Sampling Mythology and sample size

Sampling was carried out by using a random sampling method. In my study of farmers, the sample size was 50, which is the greatest than other respondents (suppliers, retailers) because farmers are the ones who produce a large number of tomatoes, and loss occurred higher than

suppliers and retailers due to the lack of knowledge about different postharvest technology like optimum harvesting period, method of harvesting, lack of grading, lack of handling technology, lack of suitable packaging materials, lack of storage facilities, etc. This study has used 50 sample sizes for farmers/ producers among 100 samples. In the remaining 50 samples, I have used 25 samples for suppliers and 25 for retailers. The target groups with their respected sampling size are shown in the table below:

Table No. 4.2 Targets groups of sample size

S. N	Target group	Sample size
1	Farmers	50
2	Suppliers	25
3	Retailers	25
	Total	100

Source: Field survey, 2020.

4.3.4 Sources of information and data collection

The survey was completed primarily by collecting primary data and was supported by secondary data to the same extent. Primary data was collected from the field survey. Secondary data was collected by reviewing various published and unpublished documents related to research topics.

A field survey was conducted using a questionnaire to collect primary data. The source of the primary data was obtained through visits by tomato producers, wholesalers, and retailers.

4.3.5 Questionnaire

The investigation entitled “Study on the Postharvest Losses of Tomato during the Supply Chain System” was conducted in the Kavrepalanchok district with farmers, suppliers, and retailers involved in the overall supply of tomatoes. The significant result and findings obtained were presented in the following sector.

4.3.6 Data processing and analysis

The information collected from the survey was first encoded and entered into the computer. Descriptive statistics such as mean, standard deviation, percentage, and frequency were used to

process the data. Data entry and analysis were done using computer software such as Microsoft Excel. Analytical data was present in tables, graphs, and pie charts.

4.4 Result and discussion

The investigation entitled “Study on the Postharvest Losses of Tomato during the Supply Chain System” was conducted in the Kavrepalanchok district with farmers, suppliers, and retailers involved in the overall supply of tomatoes. The major result and findings obtained were presented in the following sector.

4.4.1Farmers Profile

General information of the farmers

Demographic features include age, gender, and educational status of farmers.

Age of respondent

Respondents were divided into four groups based on their age (above 30, 31 - 40, 41 - 50, and above 50 years). The study shows that the majority of farmers, 32.2 percent were within the 41 - 50 age group, 16.26 percent were within the below 30 age group, and 22.2 percent were above 50 years age group. The study also shows no farmer. For the wholesaler, the study shows the majority of wholesalers, 34.2 percent were within the 40 - 50 age group, 8.4 percent below 30 age group, 26.9 percent 31 - 40 age group, and 29.8 percent above the 50-age group. For the retailers, the study shows that the majority of retailers, 35.2 percent were from the 41 - 50 age group, 28.4 percent were within the 31 - 40 age group, 13.7 percent were below the 30-age group, and 22.7 percent were above the 50-age group.

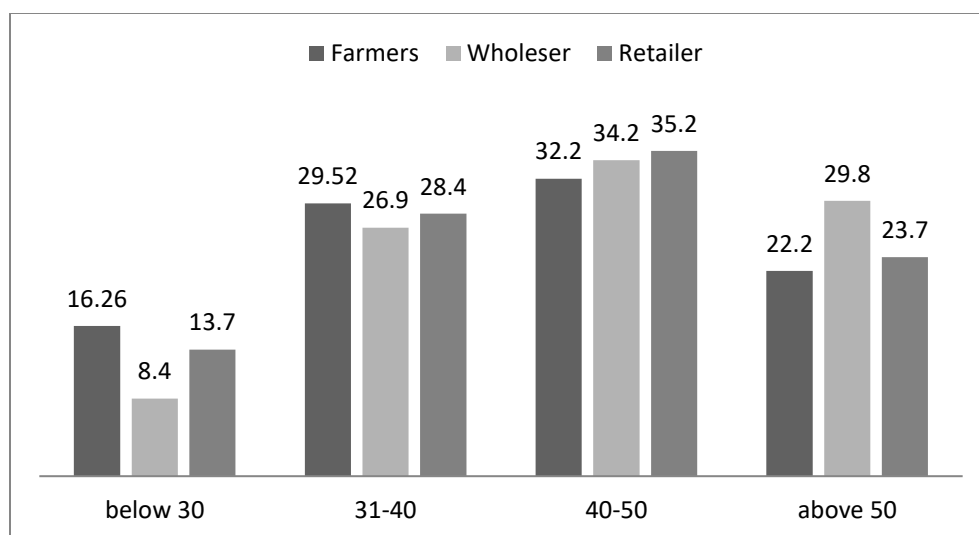


Figure: 4.2 Age of respondents, Source: Field survey, 2020.

Gender of the farmers

Both male and female genders were found to be involved in tomato production activities among farmers, wholesalers, and retailers. In the farmer's group, the majority of the population involved was male with 55.93 percent and female with 44.07 percent. In the wholesaler group's majority of the people, the male was 61.2 percent, and female 38.8 percent, was involved. In the retailer group, most people were male, 53.5 percent, and female, 46.5 percent were involved.

It was found that the majority of the male population was involved in agriculture as compared to females because females are also involved in other household works.

Literacy status of farmers

In the study area, 19.2 percent of farmers had primary level education, 36.14 percent had secondary level education, 27.76 percent of farmers had intermediate level education, and 17.2 percent had university-level education. No farmers were illiterate. In the case of wholesalers (suppliers), almost all were educated. Among them, 25.67 percent of wholesalers had primary level education, 30.33 percent had secondary level education, 21.2 percent of wholesalers had intermediate level education, and 22.8 percent had university level education. Among retailers, 29.2 percent of retailers had primary level education, 31.34 percent of retailers had secondary

level education, 21.8 percent of retailers had intermediate level education, and 17.66 percent of retailers had university-level education. Most of the literate people were engaged in other kinds of jobs in urban areas, so illiterate people were engaged in agriculture.

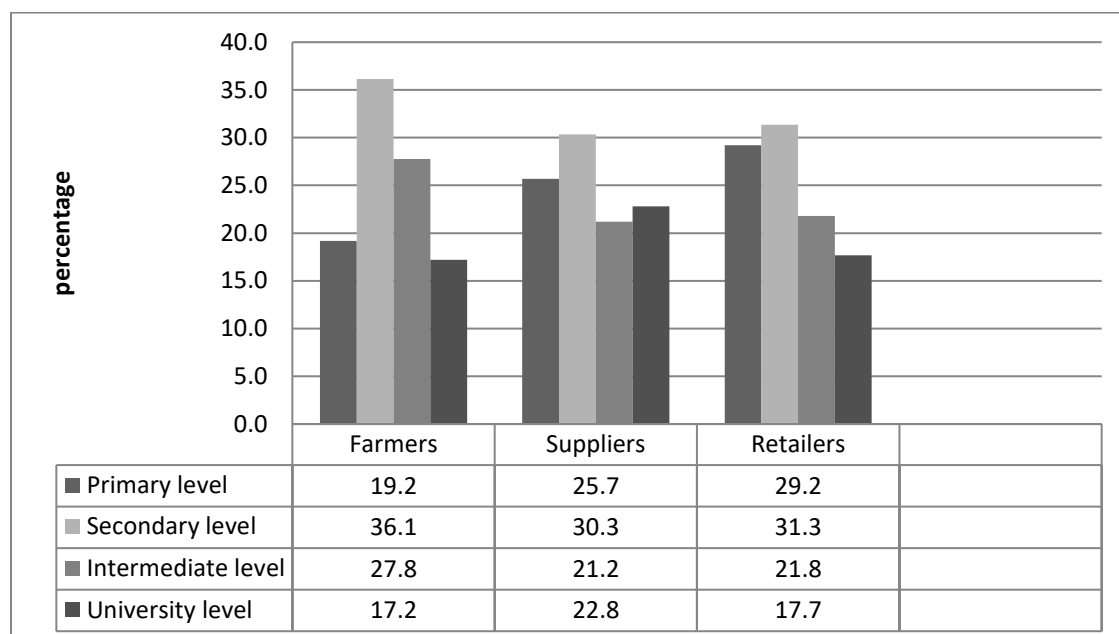


Figure: 4.3 Literacy statuses of respondents, Source: Field survey, 2020.

Information about Land, Production and Income

Land and production information includes:

- The area of tomato production.
- The volume of production in a year.
- Season of production.
- Average income from tomatoes in a year.

Production area of Tomato

Field information shows that under tomato cultivation, the majority of farmers, 39.23 percent had below 0.25ha of land; 31.2 percent of farmers had 0.25 - 0.5 ha of land; 17.96 percent of farmers had 0.5 - 1ha of land and 11.61 percent farmers had more than 1 ha of land.

The majority of farmers didn't have a larger area of farming land, so they produced tomatoes within the land available to them, which was comparatively small. Larger scale tomato producers had leased land from others and produced tomatoes on a commercial scale.

Distribution of Respondents according to their Volume of Production in a year

The farmers whose total tomato production was under 1 - 500 crates per year were considered small-scale producers, 501 - 1000 crates were moderate producers and 1001 - 1500 crates were large-scale producers. Field information showed that 72.2 percent of farmers were small-scale producers in production volume. However, by land area, 55 percent were small-scale producers. And 13.7 percent of respondent farmers were large-scale producers by volume of production. This signified that the farmers who produced 1001 - 1500 crates were less.

The result showed that most farmers did not have their land for large-scale farming. For larger-scale agriculture, they had to lease other lands of production, which resulted in a larger volume of production.

Table No. 4. 3 Distribution of respondents according to their volume of production in a year

Range of production (crate)	Total production (crate)	Percentage (%)
Small scale (1-500)	7,895	72.2
moderate (500-1,000)	1,550	14.1
Large scale (above 1,500)	1,500	13.7
Total	10,945	100

Source: Field survey 2020.

Distribution of respondents according to their frequency of production in a year

The frequency of tomato production practices of farmers of the Kavrepalanchok district varied from 1-3 times a year. The survey showed that 5.6 percent of farmers produce tomatoes three

times a year. Similarly, 13.7 percent had made tomatoes twice a year. The majority of farmers, 80.7 percent, had grown tomatoes once a year. The farmers who produced tomatoes three times a year were commercially large-scale producers in terms of land, the volume of production, and frequency of production as well. These category farmers applied farming techniques such as plastic tunnels and drip irrigation facilities where small producers had less knowledge of farming techniques.

Distribution of farmers according to their income from tomato production annually

The information showed that 44 percent of farmers made income ranging from 10,000 to 50,000, significantly less than those who made income up to 300,000.

In support of previous discussions, farmers who have rented large tracts of land and a high frequency of cultivation have made more money than cultivating tomatoes on their small area of land and producing tomatoes only once a year.

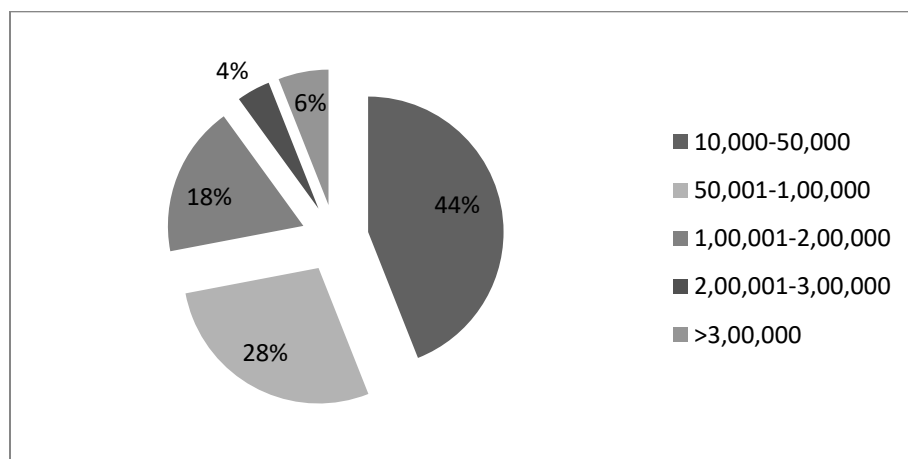


Figure: 4.4 Distribution of farmers according to their income (NRs) from tomato production annually, Source: Field survey, 2020.

Distribution of farmers at the stage of harvesting

Different farmers harvest the tomato at different stages. The farmers harvest the product by manual handpicking. The frequency bar graph shows that most farmers harvest tomatoes at the mature green stage 39.7 percent for the long-distance market. Similarly, among some farmers,

27.76 percent harvest the product at a pink stage, 12.23 percent at the soft ripe stage, some 20.47 percent at the challenging ripe stage, and no farmer harvest at the immature stage. So, we can suggest that the farmers harvest tomatoes at the mature green stage, which helps to increase the shelf life of tomatoes, and they can be kept for a longer time.

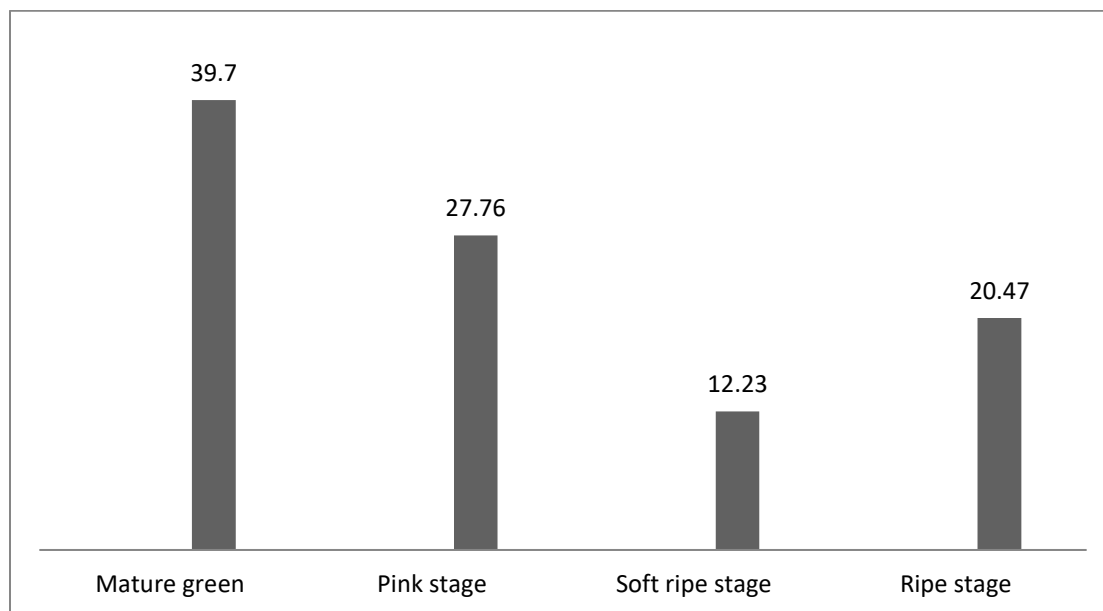


Figure: 4.5 Distribution of farmers at the stage of the harvesting, Source: Field survey, 2020.

Losses of tomato in farmer side

The losses of tomatoes were highly seen during harvesting, handling, packaging, storage and transportation. In relation to this, other losses were seen caused by insect pests such as tomato fruit and shoot borer, Tutaabsulata, and pathological factors such as yellow leaf curl, late blight etc.

Loss of tomato during harvesting

The harvesting section includes edible crops left in the field, plowed into the soil, and eaten by pests; the harvest timing is not optimal and is lost due to poor techniques. According to site information, 6 percent of losses occurred during the harvesting process by farmers on the farm. These losses mainly included entomological factors such as tomato fruits and shoot bowlers and

pathological factors such as late yellow cigar blight. Other losses were due to the rough handling of tomatoes and premature harvesting.

Losses of tomato during packaging

In the case of packaging materials, the majority of the respondents used plastic buckets, 74 percent, whereas 14 percent and 12 percent used crates and doko (bamboo baskets), respectively.

The plastic buckets were highly used as packaging materials due to their ease of use and availability. Farmers can easily carry tomatoes from one place to another in such buckets. Crate and doko were less used as farmers felt inconvenient taking on them.

The total loss of tomatoes during packing was found to be 4 percent. The information showed that the significant loss occurred during the packaging. The comparative physical losses became the major deficit after harvesting tomatoes. These losses factors include rough handling, bruising and physical pressure which destroy the shape and physiological structure of the tomato.

Loss during storage

Farmer's store tomatoes in the open field for only a few hours or a day after harvest. The store was not facilitated; losses incurred during storage are 1 percent. The suppliers came and collected the tomato within a few hours of harvesting. But sometimes, suppliers do not come on time to pick up the harvested tomato. In that situation, the number of losses will be high. Loss during storage was negligibly less, as reported by farmers during data collection.

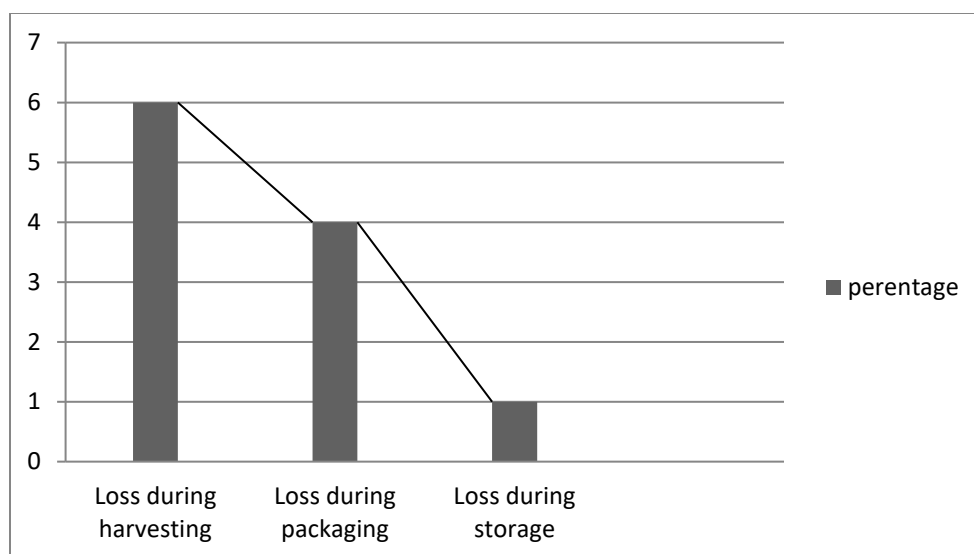


Figure: 4.6 Farmers side losses, Source: Field survey, 2020.

4.4.2 Supplier's profile

Distribution of suppliers according to their collection of tomato during one time

From supplier information, 29.4 percent of the suppliers were small suppliers who collected 525 crates of tomatoes at a time. Similarly, 36.7 percent were moderate scale suppliers who collected 655 crate tomatoes at a time, and 33.9 percent were large scale suppliers who collected 605 crate tomatoes.

This survey shows that large suppliers collected up to above 120 crates at a time, which was relatively high compared to medium and small suppliers. The volume of collection was almost the same for all categories of suppliers. It could also be interpreted as the supply of tomatoes through moderate quantity suppliers.

Table: 4.4 Supplier's collection during one time

Range of collection	Total collection (crate)	Percentage (%)
Small scale (1-60)	525	29.4
moderate (61-120)	655	36.7
Large scale (above 120)	605	33.9
Total	1,785	100

Source: Field survey, 2020.

Loss during collection

The loss during tomato collection by the supplier was 1.5 percent. According to the data, for every 1785 tomato crate collection, around 27 crates were wasted.

The significant losses during the supplier's collection process were physical and mechanical. This type of loss occurred while transferring from a farmer's bucket or crate to the supplier's packaging and uploading it to the supplier's vehicle.

Loss during transportation

The result showed that the loss that occurred during transportation of tomatoes from farmer's field to wholesaler's distribution was 3.5 percent.

These were mainly physical losses that occurred due to the bumping of roads and vehicles while traveling from one place to another. Though the crates were used as packaging materials, physical and mechanical damage occurred due to the imbalanced structure of the road, sometimes because of the pressure of crates inside the vehicles.

Loss during storage by suppliers

The information showed around 1 percent loss during the storage by suppliers. The suppliers do not have to store tomatoes before supplying them to retailers. They sold tomatoes as soon as they brought them to their market distribution center.

Loss of suppliers during selling and selection process by retailers

The result showed a 3 percent loss of tomatoes during the selling process by suppliers. While selling 1785 crates of tomatoes, 56 crates were wasted.

These losses occurred when negotiating with retailers while on the supplier side. Retailers roughly treated tomatoes when selecting and removing unhealthy tomatoes at the time of purchase. In many interactions of tomatoes with the retailer selection process, good tomatoes can also be destroyed initially.

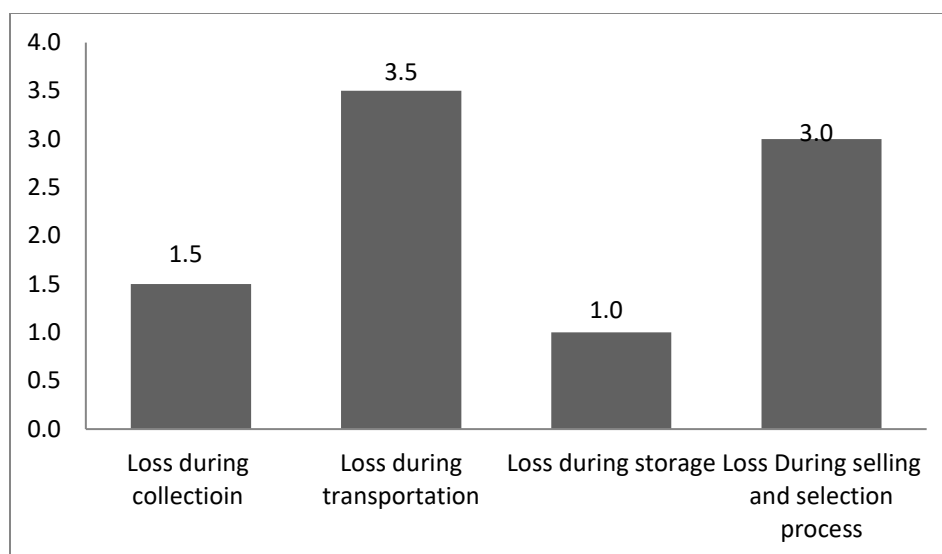


Figure: 4.7 Losses from supplier's side, Source: Field survey, 2020.

4.4.3 Retailer's profile

Retailer's behavior of purchasing tomatoes

According to the information, 56 percent of retailers were small retailers who afford to buy up to one crate of tomatoes at a time. Large retailers purchased up to two crates at one time. Retailers' buying behavior was related to their ability to sell to customers. Most retailers can sell up to one crate at a time.

Table No. 4.5 Retailer's behavior of purchasing tomatoes

Range of collection (crate)	Total collection (crate)	Percentage (%)
Small scale (up to one)	14	56.0
moderate (above one))	11	44.0
Total	25	100.0

Source: Field survey, 2020.

Distribution of retailers during collection

Retailers lost 3 percent when collecting tomatoes from suppliers; while collecting 25 tomatoes, 0.65 crates of tomatoes were wasted. 72 percent of retailers bought tomatoes below the crate;

they could select tomatoes and only pick up the good ones. In this process, losses to retailers were significantly less. Retailers couldn't choose a good one when to buy tomato crates. In this case, they took some potentially wasted tomatoes inside the basket, which caused a loss to the 3 percent of retailer side

Loss of tomato while transporting from suppliers POS to retailers POS

The loss of tomatoes in transit from the supplier's delivery point to the retailer's selling point depends on the mode of transport. The results showed that retailers used bicycles, motorcycles, DI vans, and self-carrying modes of transportation to transport tomatoes from the supplier's distribution point.

Distribution of respondents according to their use of packaging materials during transportation

The results showed that 36.0 percent of retailers use polythene bag as packets and 36.0 percent use crate to transport tomatoes from their suppliers. Retailers carrying tomatoes on bicycles or public transport used polythene bags for their convenience. Others, who bought tomatoes, a crate or two, used motorcycles and other vehicles of their convenience to carry tomatoes from suppliers. Packaging materials play a significant role in controlling postharvest losses, and the study finds education has affected packaging material selection.

Table No. 4.6 Distribution of respondents according to their use of packaging materials during transportation

Items	Primary level		Secondary level		intermediate level		University level		Total	
Polythenebag	4	[57.1] (44.4)	4	[44.5] (44.4)	1	[20.0] (11.2)	0	[0.0] 0	9	[36.0] (100)
Bamboo basket	1	[14.2] (14.28)	3	[33.4] (42.8)	1	[20.0] (14.2)	2	[50.0] (28.5)	7	[28.0] (100.0)
Crate	2	[28.7] (22.2)	2	[22.1] (22.2)	3	[60.0] (33.3)	2	[50.0] (22.2)	9	[36.0] (100)
		[100.0]		[100.0]		[100.0]		[100.0]		[100.0]
Total	7	(28.0)	9	(36.0)	5	(20.0)	4	(16.0)	25	(100.0)

Source: Field survey, 2020.

Total loss occurred until tomato reaches to retailers Point of sales (POS)

The results showed that at the retailer's point of sale, the loss of tomatoes during transporting from suppliers was 2 percent, while at 25 crates transporting, there was a loss of 0.42 crates.

The losses incurred during shipping from retailers to suppliers were physical and mechanical. During the transportation, the tomatoes were damaged due to vehicle collision, loading and unloading process of tomatoes, and pressure while carrying in polythene.

Loss in tomato during storage by retailers

The results showed that retailers' loss of tomatoes during storage was 2 percent. There was a loss of 0.35 crates when storing 25 crates of tomatoes.

Retailers have to store their unsold tomatoes in their ordinary rooms. They do not have proper storage facilities for tomatoes. Tomatoes are perishable, so if retailers have to keep them for a day or more, the unsold tomatoes will be damaged.

Loss during retailing

The loss of tomatoes in retail sales is 4 percent. The data show that one crate of tomatoes was wasted while selling 25 crates of tomatoes. In retailing, the consumers had to shuffle tomatoes to select good tomatoes during their purchase. While multiple shuffling by consumers, some good tomatoes get physically damaged and bruised, which were then removed as waste, the retailers also reported a significant loss of good-quality tomatoes during this process.

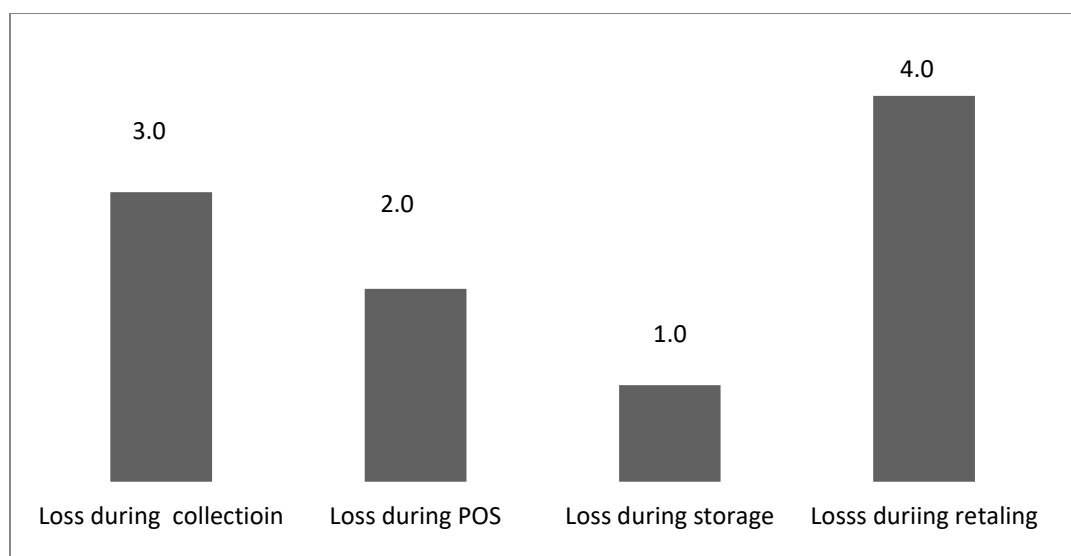


Figure: 4. 8 Retailers losses, Source: field survey, 2020.

Summary Chart

According to the survey, the total loss of tomatoes in the supply chain was 30 percent from harvest to retail sales. Of this, 6 percent of losses were incurred during the harvesting process by the farmer's fields. 4 percent of the loss occurred during the packaging process by farmers. 1 percent of losses occurred on the farmer's side during the storage process. 1.5 percent of losses occurred during collection by suppliers. 3.5 percent of losses occurred during the transportation process by suppliers. 1 percent of loss occurred during store by suppliers. 3 percent of losses occurred during the supplier's POS. 3 percent of losses occurred during collection by retailers. 2 percent of losses occurred during transportation by retailers. 1 percent of losses occurred during storage by retailers. 4 percent of losses occurred during retailing. The majority of losses, 6 percent of tomatoes in the supply chain, were found during the farmer's harvesting process.

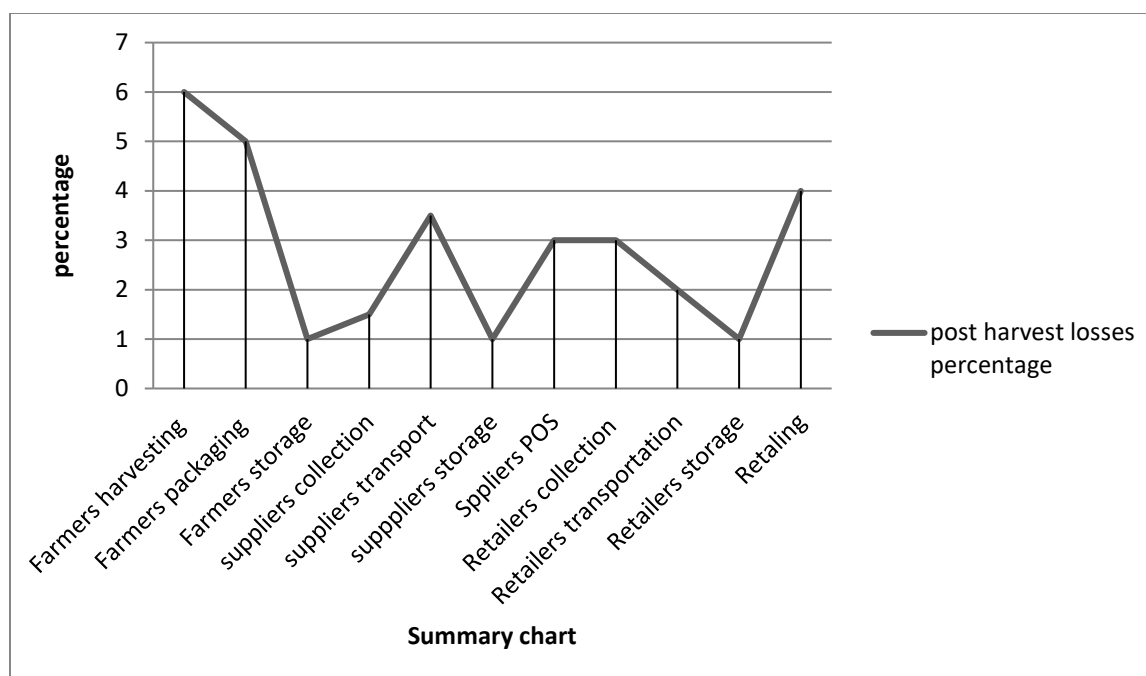


Figure: 4.9 Postharvest losses of tomatoes during the supply chainsystem, Source: Field survey, 2020.

4.5 Summary and conclusion

Tomato (*Lycopersicon esculentum* Mill.) belongs to the family Solanaceae, one of the most universally known, widely consumable nutritious and widely grown vegetables globally. The study was confined to the Dhulikhel Municipality, Banepa Municipality, Panauti Municipality, Panchkhal Municipality, Namobuddha Municipality, and Mandandeupur Municipality Kavrepalanchok district, mainly concentrating on postharvest losses of tomato during supply chain systems.

The overall loss of tomatoes in the field harvest to the retail supply chain was 30 percent. The major loss of tomatoes in the supply chain was discovered during the farmer's harvesting process. Primary data was collected from field surveys, and secondary data was collected through reviews of various published and unpublished documents, reports, research texts, books, pamphlets, and research reports.

A total of 100 samples were taken for the study, of which 50 were farmers, 25 suppliers, and 25 retailers. The sampling method was a random sampling of the research methodology. Data collected from the field was digitized in MS Excel, and further analysis was done using various features of MS Excel. The units of data were standardized into a single unit for uniformity of results and analysis. In this study the quantity of tomatoes was measured in Crate and area of land was measured in ropanies¹⁸³ and hectares. The analyzed data were presented in tables and charts.

In many developed countries, crop losses from farmers are relatively low. Because they do not have to cut their product on their own, farmers cultivate food and sell it before harvesting.¹⁸⁴ But in a third World country like Nepal, pre-harvest marketing is not popular. They have to go through the whole process up to packaging. Farmers are not aware of the harvesting methods and not available even modern technology. Therefore, the deficit after harvesting from the farmer's side is relatively high.

In Nepal, postharvest losses of tomatoes are relatively high compared to other developing countries. Postharvest losses of tomato in Coimbatore district of Tamil Nadu, India, occur up to 26 percent and postharvest losses. The loss on the part of the retailer is higher than that of the farmer side.¹⁸⁵

Some other researchers have quoted producers as having played an essential role in reducing postharvest losses on tomatoes in Nepal. Farmers have relatively low losses, but I disagree; this survey shows that the farmer's side has higher losses than the other sides. The reason for high losses on the farmer side is education level, farming equipment, age, harvesting technology and tools, packaging tools, storage facilities, production size, etc.

In the tomato production area, 55 percent of the farmers were small-scale producers, 31 percent were medium-sized producers, and 14 percent were large-scale tomato producers. About 40

¹⁸³One ropani equal to 508.74 square meters.

¹⁸⁴Deribe, H. (2016). pp.72-77. In Nepal, the pre-harvest marketing system is being introduced in the case of fruits like oranges and apples, but not in the vegetable sector.

¹⁸⁵See, Kalimuthu, et al. (2014). pp. 1-7. Geographical conditions, market channels and equipment used during harvest time play a major role to control postharvest losses.

percent of farmers generate up to 50,000 NR per year, and 60 percent generate up to 300,000 NR per year.

The total loss during harvesting and packaging in the tomato supply chain was 11 percent on the farmer side. The loss in field harvesting was 6 percent, and the loss in the packaging process was 4 percent, and sometimes farmers had to store their harvesting product at that moment harvest occurs around 1 percent.

The suppliers' losses were calculated through the collection process, transportation, and distribution to retailers. The total losses of tomatoes on the supplier side were 9 percent in the supply chain of tomatoes. During collection, the suppliers had a loss of 1.5 percent, during transportation loss was 3.5 percent, during distribution loss was 3 percent, and losses during storage were 1 percent.

On the retailer's side, the total loss of tomatoes in the supply chain was 10 percent. The losses on the retailer's side were calculated through four dimensions (Collection, Transportation, Storage, and Retailing). During collection, retailers had a loss of 3 percent; during transportation, the loss was 2 percent; during storage, the loss was 1 percent; and during retailing or selling, the loss was incurred 4 percent.

The study has shown that the damage is only more in Nepal than in Tula of other Bixil countries like Nepal. In Bangladesh, tomato loss is 9.2 percent at the farmer level, 5.3 percent at the retail side, and total tomato loss is 22.9 percent.¹⁸⁶ Data shows that tomato losses in Bangladesh are less than in Nepal.

A present study shows that postharvest losses of tomatoes are relatively higher on the farmers' side. Study area farmers are not aware of their profession and do not even know about hybrid seeds and other things that can reduce postharvest loss.

This survey found the main reason behind postharvest losses in the supply chain system is the lack of knowledge about products, harvesting methods, harvesting time and technology,

¹⁸⁶Paresh, K. (2018).

geographic knowledge (climate change), packaging material, etc. It is possible to minimize the losses by providing adequate training and awareness programs at the farmer's level. Farmers are getting used to those kinds of casualties during the harvesting process; they are not even thinking of how they can reduce the massive amount of the loss by adopting some advanced and modern technology. Advanced and appropriate technology should be accessible at the farmer's level; because of the geographical condition of Nepal, there is a high rate of postharvest losses in the transportation, loading, and unloading process. I.e., while packaging tomatoes on bamboo baskets, they can use dry grass (paral) instead of cover craft. It helps reduce physical loss during shaking while loading, unloading, etc. In the case of Nepal key point of postharvest losses is the farmer side. Improving activities at the farmer level, such as harvesting tools and methods, harvesting timing, packaging material, grading, sorting, etc., can reduce losses farmer's level, wholesaler level, and retailer's level.

Manly losses occur at the supplier level during the transportation and selling process. Due to the jumping and pumping road and lack of the refrigerator transport vehicle, unnecessary losses are arising. Transporting at night is one of the best ways to Nepalese situation. It helps control temperature and less chance of shaking than in the daytime.

The second most significant losses occur in the supply chain system at the retailer's level because of the packaging material, customer behavior, and lack of storage facilities. In this case, retailers may use wooden boxes to carry tomatoes instead of plastic bags. It helps to control the damage caused by compression.

There are underlying factors affecting Postharvest losses in the Kaverepalanchok district. Some may require solutions involving direct communication and awareness-raising among the farmers, suppliers, and retailers about the importance of reducing food waste. Other requirements include the government supporting and intervening in the agriculture industry. For example, improving the clarity of food date labeling and advice on food storage, introducing modern technology to the farmer level, building the road & other essential infrastructure, providing agro-loan in minimum or without interest, training, and farmer's consciousness ceremony, etc.

Technology transfer from developed countries to Nepal could reduce postharvest losses. Innovative ideas and prototypes must be brought to the community to enhance the postharvest activities and reduce losses; advanced technologies should be introduced at the farmer level. Develop and promote a package of practice based on area-specific needs and identified challenges, followed by training to enhance the skills and knowledge of farmers, suppliers, and retailers in postharvest management.

I believe that if the above suggestions and advice are heeded, agriculture in Nepal could be greatly improved.

Chapter 5 Climate change and its effects on postharvest losses (131-164)

5.1 Introduction

The challenge of climate change has often been the debate between developed and developing countries in international fora, whether it be mere news or academic content for those struggling with daily livelihood struggles and busy routines. But the truth is that this problem, which adversely affects air, water, agriculture, food, health, livelihood, housing, etc., sooner or later, affects our lives. Farmers are suffering from anomalous monsoons or water crises. They all suffer from climate change, whether they are fighting a strange illness caused by extreme weather, which are direct effects on postharvest losses.

Climate change refers to any change in climate over time, whether due to natural variability or as a result of human activity.¹⁸⁷ Climate is changing day by day, and there are two main reasons for these changes. Firstly, due to the interference of human activities in the form of burning of the atmosphere, fossil fuels and agricultural activities leading to the emission of greenhouse gases are due to increased amounts of greenhouse gases in the atmosphere in recent times. Despite the many adverse effects, some beneficial aspects of enhanced greenhouse gas effects exist. The higher atmospheric concentration of CO₂ in rice, wheat, and soybeans can increase the production of crops.¹⁸⁸

¹⁸⁷World Health Organization (2016). pp. 1-4.

¹⁸⁸Taub (2010).

Nepal's agriculture faces many obstacles and problems, but the biggest problem in recent years is climate change, which is adversely affecting Nepal's agricultural sector. Lack of preparedness to combat climate change shows dire consequences for people's lives and the economy.

Nepal is a mountainous country consisting of the three ecological regions running north to south: Mountain, Hills, and Terai. About 2.35 million hectares of the country's total land area is arable for agriculture.¹⁸⁹ Nepal is an agricultural country and is richly endowed with numerous crops and plants. The temporal, altitudinal, and topographical variation has made agricultural diversity possible in Nepal. Agriculture is the mainstay of the Nepalese economy, and around 68% of Nepal's population is engaged in agriculture.¹⁹⁰ pre-dominantly of subsistence nature which provides food and livelihood security to a substantial section of the Nepalese population accounting 23.13% of GDP.¹⁹¹ Nepal's agriculture is mainly rain-fed, and its contribution to the GDP and food security depends on the monsoon rain characteristics. Any extent of change in climatic variables, therefore, directly affects agriculture performance. However, climatic variability and uncertainty change have posed increasing threats to agriculture.

Nepal's livelihood and economy are directly related to agriculture, so GDP cannot remain unaffected by climate change. Climate change directly impacts Nepal's economy by correlating with water, forests, and agriculture. According to a 2014 Ministry of Science, Technology, and Environment survey on the economic impact of climate change, climate change has a direct effect of 1.5% to 2% of annual GDP.

In recent years, the effects of climate change, such as rising temperatures, increasing frequency of heavy rainfall or drought, declining crop quality, changes in the distribution of livestock and plants, and increasing exposure to global warming, have been felt worldwide.¹⁹² Agriculture is sensitive to climate change, as crop production is highly dependent on climate resources such as temperature, solar radiation, and rainfall. Therefore, the recent high-temperature trends in summer and global climate change called "global warming" are considered urgent to explain crop production's possible effects and test adaptive measures to mitigate the impact.

¹⁸⁹The World Bank (2018).

¹⁹⁰USAID (2022).

¹⁹¹The World Bank (2020).

¹⁹²Food and Agriculture Organization (2015). pp. 30-56.

Climate change is variations in the earth's global or regional climates over time. It is a change in the environment attributed directly or indirectly to human activity that alters the composition of the worldwide atmosphere. Climate change is a phenomenon due to emissions of greenhouse gases from fuel combustion, deforestation, urbanization, and industrialization, resulting from variations in solar energy, temperature, and precipitation. Climate change is an emerging environmental challenge, is a natural process, and has been considered through increased rainfall variability and uncertainty. Greenhouse gases (GHGs), mainly CO₂, N₂O, and CH₄, majorly emitted from the energy sector, are the primary contributing agents of climate change.¹⁹³ Carbon Dioxide (CO₂) emission is the primary element that forms more than 80 % of the total GHG. GHG has created a greenhouse effect, subsequently altering precipitation patterns and global temperatures. According to the National Communication Report of the Government of Nepal, net CO₂ emission was about 9.747 tons, and the net CH₄ emission was estimated to be 0.948 tons in 1994.¹⁹⁴

Agriculture is the primary land use around the world. Agricultural production is highly climate-dependent since crop growth is influenced by solar radiation, temperature, and rainfall. Agriculture is also sensitive to climate variability and weather extremes (droughts, floods, and severe storms). Climate change is projected to impact local agriculture, and the net result can be harmful such as persistent drought, agricultural land or beneficial CO₂ and Salinization of the longer growing season, and increased rainfall to increase the high yield. However, due to climate change and greenhouse gas emissions, agricultural production has many effects on the farming sector. Only about 25% of global greenhouse gas emissions are carbon (due to deforestation) and 50% methane (rice and livestock production). From) the contribution is responsible for 75% nitrous oxide (due to nitrogenous fertilizers).

Industrialization and the number of vehicles is constantly increasing. As a result, the world is concerned about rising global warming due to increasing greenhouse gas emissions and climate change. This is also a matter of concern because Nepal is an agricultural country, and agriculture is the cornerstone of Nepal's economy. Today, mechanization is also taking place in agriculture,

¹⁹³Kehinde (2020). pp. 3-7.

¹⁹⁴Publish in the Himalayan times' topics on the climate change threat on 12 Sep 2016 by Sharad K. Shrestha.

due to which the atmosphere is getting warmer because of more emissions of gases like carbon dioxide and nitrous oxide.

According to a NASA report, the atmosphere's average temperature rises by 0.8 degrees Celsius. The most significant impact of soil temperature has been on agriculture. According to the Food and Agriculture Organization (FAO), Nepal is among the top 11 countries most affected by climate change; winter temperatures could rise by 3 to 4 degrees Celsius by 2050.

Nepal's water resources and reserves are rapidly declining, and farmers will soon be forced to abandon traditional irrigation methods and use modern techniques and crops to reduce water consumption. The adoption of the IPCC report warns that global warming could lead to severe water and food shortages. In some areas, food production may decline by up to 50 percent.

According to research, if the average atmospheric temperature increases by 1 degree Celsius, it reduces the yield of wheat by up to 17 percent.¹⁹⁵ Climate change will also have a disastrous effect on wildlife, and melting glaciers will lead to water scarcity in the areas where these glaciers are the source of drinking water. On the other hand, the sea level will also rise. By the end of this century, the sea level can increase by 7 to 23 inches, i.e., 18 to 59 centimeters.

At present, up to 51 percent of cultivated land has been affected due to the change in the timing of the monsoon. Rising temperature has changed the ripening of crops. The rapid rise in temperature causes the harvest to become shriveled, due to which the vegetable crops become very thin and the productivity decreases. According to a study, if the temperature increases by 1 to 4 degrees Celsius, then the production of food items can decrease by 24 to 30 percent.

The increase in the population of Nepal will increase the demand for all food items. As a result, food crisis will be a severe problem ahead for us. Climate change will affect the productivity of crops and harm their nutritional value. Flowers will bloom in fruit and vegetable crops, but they will produce very little fruit, or their nutritional value will be affected.

¹⁹⁵Piao, et al. (2017).

Climate change will not only affect crops' productivity but will also negatively impact their quality, leading to postharvest losses.¹⁹⁶ Lack of nutrients and proteins will be found in vegetables, due to which the health of humans will be affected even after taking a balanced diet.

For an agricultural country like Nepal, the composition and productivity of the soil hold an important place. Soil moisture and efficiency will be affected due to increase in temperature. Soil salinity will increase and biodiversity will decrease. With the increase in temperature, the decomposition process of carbon by the micro-organisms present in the soil will increase. As a result, the carbon and nutrients present in the soil will be depleted very soon, due to which the soil will become barren.

Due to climate change, the number of pests and diseases will increase. Warm climate is helpful in increasing the fertility of insect moths. Along with the increase in pests, excessive insecticides will be used for their control, which will give rise to many types of diseases in vegetables and plants.¹⁹⁷ Unhealthy product will damage soon and it is difficult to manage nutrition value during storage.

The biggest impact of climate change will be on water resources, there will be a serious problem of water supply and drought and flood conditions will be created. In semi-arid regions, the dry season will be longer, which will adversely affect the productivity of crops. Uncertainty of rainfall will also affect the production of crops, due to high temperature and lack of rainfall, ground water resources will be over-exploited for irrigation.¹⁹⁸

Crops require more irrigation with increasing temperature in this case conservation of soil moisture and collecting rain water and using it for irrigation can be a useful and helpful step. Through watershed management we can store rain water and use it as irrigation this will not only provide us with irrigation facilities but will also help in recharge of ground water.¹⁹⁹

¹⁹⁶Moretti, et al.(2010). pp. 5-13.

¹⁹⁷Food and Agriculture Organization (2021).

¹⁹⁸Arnell & Lloyd-Hughes (2014). pp. 127-140.

¹⁹⁹Duveskog (2003). pp. 12-29.

Considering climate change's profound, far-reaching effects, seed varieties suitable for the new season should be developed. Types that can withstand high temperatures, drought, and flood risk should be developed. Along with climate change, we will also have to change the pattern of crops and the timing of their sowing. Threats of climate change can be tackled by mixed farming and intercropping. To save Nepalese agriculture from the ill effects of climate change, we must make judicious use of our resources and apply our traditional knowledge by adopting the Nepali philosophy of life. Now there is a dire need that we have to give importance to such eco-friendly methods in farming, by which we can maintain the productivity of our soil and save our natural resources.

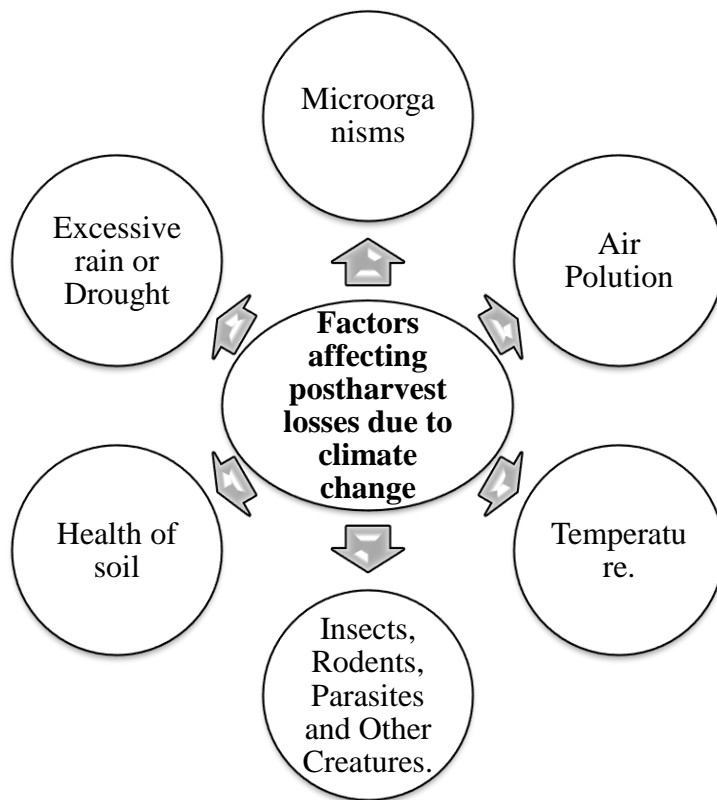


Figure: 5.1 Factors effecting postharvest losses due to climate change, Source: By authors

5.1.1 Statement of the problem

In Nepal, the arable land is 14.7 percent, including forest, shrubs, grasslands and snow areas, rocks, rivers, housing, etc.²⁰⁰The crop produced at the site was insufficient for four months (NTNC, 2004/5). Since agriculture depends mainly on monsoon rain, therefore agricultural production is marginal. Climate change has affected rainfall patterns, rainfall amount, and temperature, harming crop calendar and productivity. Overall, climate change has already started altering growing seasons, planting and harvesting, water availability, pest, weed, and disease on Terai and high hills. MoPE (2004) analyzed the impacts of climate change on Pre and Postharvest in different physiographic regions of Nepal. Though much research at the government and non-governmental level has been done and our knowledge of climate change has increased significantly, research on climate change's impact on agriculture is minimal. Because of inadequate research, understanding of climate change impacts on agriculture in Nepal is almost none. Most of the farmers are not aware of how the climate changes are leading to postharvest losses.

This is due to a lack of knowledge and information about climate change first and how it has been affecting agriculture in our society. Therefore, this study helps to assess how climate change has been affecting agriculture at different scales have been carried out. There is a lack of accurate database neither on climate nor on the long-term production database of the environment-sensitive sectors required to formulate or reformulate national policies and strategies. Also, this study contributes to creating a database of climate knowledge based on globally valued climate change issues in the agriculture sector. For the researchers, this study can be valuable for agricultural testimonials combating climate change. As far as climate change is concerned, the most significant impact has been on agriculture. Although research on climate change has been found in the agricultural sector, however, there is only few research on the relationship between climate change and postharvest losses. As a result, an important part of the effects of climate change on agriculture seems to have been lost. The objective of the study is as follows.

²⁰⁰The World Bank (2015).

This study aims to know Nepal's changing climate and its effects on the agriculture sector.

To know the relation between climate change and postharvest losses

To understand how climate change affects the supply chain and determines how to mitigate its impact

5.2 Literature review

Industrialization and the increasing number of vehicles are constantly increasing. As a result, the world is concerned about global warming due to greenhouse gas emissions and climate change.²⁰¹As Nepal is an agricultural country, it is also a matter of concern. And agriculture is the cornerstone of Nepal's economy. Agriculture is now mechanized, with more emissions of gases such as carbon dioxide and nitrous oxide warming the atmosphere. According to a NASA report, the average temperature of the atmosphere is rising. 0.8 degrees Celsius has hit the agriculture sector the hardest. Food and Agriculture Organization (FAO) data show that food production declined by 40 to 31 percent between 1996 and 2006. According to a study, winter temperatures could rise by 3 to 4 degrees Celsius by 2050.²⁰² Monsoon rainfall is estimated to decrease by 10 to 20 percent. Changes in precipitation will adversely affect crop productivity and quality.

We, humans, need plants to maintain our existence. Everything we eat includes plants or animals that depend on plants somewhere along the food chain. Plants are also the backbone of natural ecosystems. Plants absorb up to 30 percent of the carbon dioxide emitted by people every year. But climate change continues to have harmful effects on it. Rising CO₂ levels in the atmosphere and warmer temperatures affecting plants are a big issue for food security.

Plants use sunlight and carbon dioxide from the atmosphere for photosynthesis. This process produces oxygen and carbohydrates that are used for plant energy and growth. Elevated atmospheric CO₂ levels increase plant photosynthesis. This effect is called the carbon fertilization effect. Between 1982 and 2020, photosynthesis around the world increased by

²⁰¹Mgbemene, et al. (2016). pp. 301-316.

²⁰²Case, et al. (2018). pp. 5-9.

12%.²⁰³This monitored atmospheric CO₂ levels and increased them by 17%. This increase in photosynthesis was due to the use of more carbon dioxide.

About one-third of the food produced for human consumption is lost or wasted. That represents a cost of US \$ 2.6 trillion each year, including US \$ 700 billion in environmental costs and US \$ 900 billion in social costs. In sub-Saharan Africa, the annual value of postures grain losses is US \$ 4 billion, more than the total food aid the region has received over the past decade.²⁰⁴

The researchers said climate change will lead to frequent and severe extreme weather events, including extreme rainfall, wind disturbances, heat waves and droughts. Those changes help to increase postharvest losses. Vegetables are extremely responsive to wind protection,²⁰⁵ Depending on the nature of the vegetables some vegetables are necessary to dry in the sun for some time after harvest; those vegetables get more affected by wind disturbance.

Effects of climate change on agriculture and postharvest physiology have been rapidly increased.²⁰⁶ Over time, it is becoming a significant challenge to the agriculture sector and food security. Climate change has had a definite negative impact on food crop production. For example, lack of irrigation water, increase in temperature, and decline in crop production is sure to lead to deterioration in production quality.²⁰⁷ Loss of product quality is likely to cause rapid deterioration of vegetables after harvest. This helps in increasing the number of pests in stored food products as well as favorable growth of toxic bacteria and subsequent infections,²⁰⁸ which are leads to post harvest losses of product.

One of the significant challenges to the country's food security is climate change and its effects, such as frequent droughts, mid-season droughts, cyclones, floods, heat waves, cold waves, and saline water entering coastal areas. Temperatures are projected to rise by 1 to 2.5 degrees Celsius by 2050, which will have a severe impact on production.²⁰⁹ High temperatures shorten crop

²⁰³Priyanka, (2021).

²⁰⁴Food and Agriculture Organization (2019).

²⁰⁵Houdes, et al. (2006).

²⁰⁶Sargent, et al. (2010). pp. 1824-1832.

²⁰⁷De pinto, et al. (2012).

²⁰⁸Schmidhuber, et al. (2007).

²⁰⁹Marchal, et al. (2011).

duration, alter photosynthesis, increase crop respiration rate, and affect germ populations.²¹⁰ In addition, climate change converts nutrients from organic to non-organic and affects the efficiency of manure use. At the same time, it also increases vapor transpiration from the soil, which ultimately leads to the depletion of natural resources. Climate change directly or indirectly affects crops, water and soil as it affects water availability, drought intensity, microbial population, soil organic matter deficiency, low yields, declining soil fertility due to soil erosion, etc. all those factors directly effect on postharvest losses, so climate change cannot avoid.

Many factors affect postharvest losses, including crop soils, from handling of produce to storage stages. Pre-harvest production practices also seriously affect postharvest losses.²¹¹ Plants need a constant supply of water for photosynthesis and transpiration. Too much rain or irrigation can cause damage to the product or yields unhealthy product that could be a significant cause of postharvest losses.²¹²

The Economic Survey 2017-2018 warns that climate change could reduce annual agricultural income by 15 to 18 percent and the non-irrigation sector by 20 to 25 percent. Lack of adequate nutrition can lead to malnutrition, putting people at risk for health problems. Plants lose water due to high temperatures, which causes fruits and vegetables to turn gray and burst.²¹³ During the tomato cultivation season, if the temperature rises, the fruit burns and cracks.²¹⁴ If ozone reaches 50 ppb/day, vegetable production will decrease by 5-15 percent.²¹⁵

Climate Resistant Agriculture (CRA) is an approach that incorporates existing natural resources to achieve long-term high productivity and agricultural income through crop and livestock production in the face of climate change. This method will reduce poverty and hunger of the next generation keeping in view climate change. The CRA method can change the current situation and make food production sustainable from local to global in the long run. Easy access and use of technology, transparent trade, increasing use of resource conservation technology, and accessible adaptation of climate pressure by crops and pets result from climate-resistant practices.

²¹⁰Skendži'c, et al. (2021). pp. 7-28.

²¹¹Muhie (2022).

²¹²Fufa, et al. (2019). pp. 48-51.

²¹³Holcroft (2015). pp. 3-14.

²¹⁴Woolf, et al. (2000). pp. 7-16.

²¹⁵Hirpo, et al. (2019).

Climate change can affect different aspects of agriculture in the following ways:

5.2.1 Impact of climate change on crops

Based on the study, agricultural scientists found that with each 1 C temperature increase, wheat production will decrease by 4-5 million tons.²¹⁶ Similarly, with the increase in temperature by 2 degrees Celsius, paddy production will decrease by 0.75 tons per hectare. According to the Department of Agriculture, wheat production was estimated at 82 million tones, which was estimated to fall to 81 million tons due to high temperatures. Climate change will negatively impact not only crop productivity but also quality. Cereals are deficient in nutrients and protein, affecting a person's health even when eating a balanced diet.

5.2.2 Impact of climate change on soil and its effects on agriculture

For an agricultural country like Nepal, soil structure and productivity are essential. Rising temperatures will affect soil moisture and efficiency. Soil salinity will increase, and biodiversity will decrease. Rising temperatures will increase the carbon dioxide activity of soil microorganisms.²¹⁷ Healthy soil is essential to produce a quality product, and a quality product is necessary to prevent postharvest losses.

Climate change affects the world's oceans, coastlines, the environment, and human health. Now scientists have warned that climate change could also affect our precious soil. According to a study conducted by a US university, climate change may reduce the water-absorbing capacity of soils in many areas of the world. It can also seriously impact groundwater supplies, food production, postharvest losses, biodiversity, and environmental systems.

One gram of soil contains about 40,000 to 50,000 species of microorganisms.²¹⁸ Some bacteria can improve soil quality, including removing contaminants, improving fertility, and arable land to make it arable. Due to climate change, some of these organisms have been unable to survive in a changing environment which directly affects the fertility of the production and product

²¹⁶Zhao, et al. (2017). pp. 9326-9331.

²¹⁷Neme, et al.(2021).

²¹⁸Martínez-Prado, et al. (2014).

health.²¹⁹ Healthy soil is the most important nutritional product. But the recent year, due to global warming, the soil is becoming acidic, which is very harmful to the products.²²⁰

Like other parts of agriculture, the soil is being affected by climate change. The soil was becoming organic carbon-free with the use of chemical fertilizers. Now, rising temperatures will affect soil moisture and efficiency. Soil salinity will increase and biodiversity will decrease. Decreasing groundwater levels also affect its fertility. Outbreaks like floods will increase soil erosion, and drought will increase infertility. Fertile soil harvesting will help to make the field barren as it will not be able to adapt to the decay and diversity of trees and plants.

A variety of agricultural management activities can increase the carbon production of the soil and produce functional stability in the ground. Conservation agricultural techniques (crops with low mobilization, sowing, and crop rotation to support crop rotation), soil conservation practices (contours), and recharge strategies of organic matter are suitable for protective soil cover and plant growth. By providing the environment, the soil can be replenished with organic matter.

Natural element management involves using organic and inorganic fertilizers, including composting in the field, vermin compost, growing legumes in rotation, and the use of crop residues to maintain long-term soil health. Instead of combining agricultural products without crops, feeding fertile soil is an essential point of solid stability for Nepalese farmers.

²¹⁹Food and Agriculture Organization (2015).

²²⁰Meng, et al. (2019).

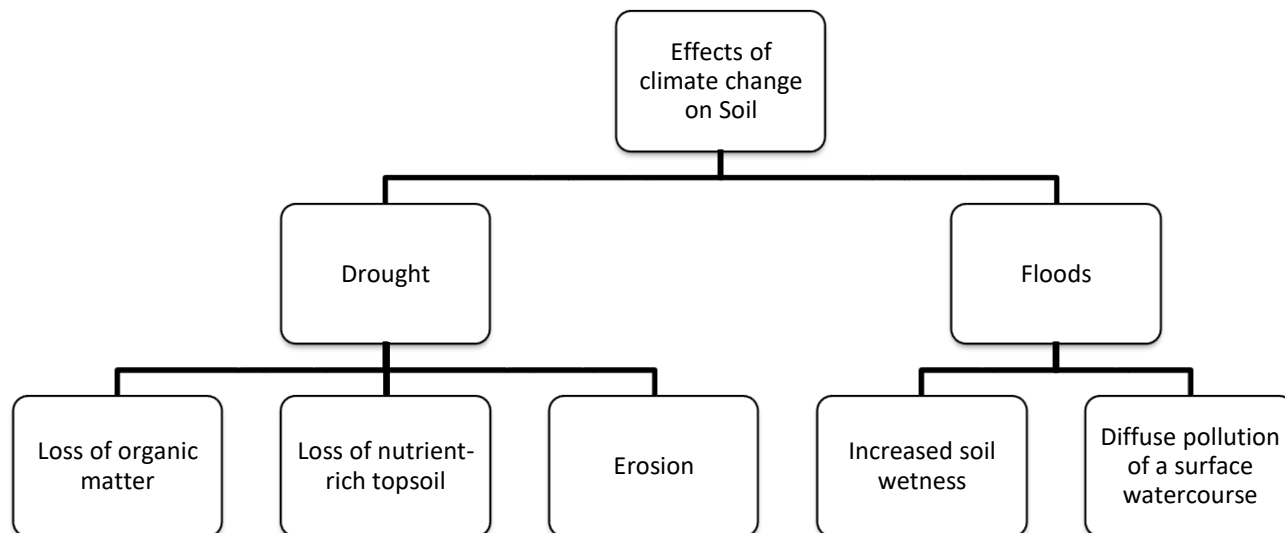


Figure: 5.2 Effects of climate change on soil, Source: By authors

5.2.3 Impact of climate change on water resources and its effects on postharvest losses

The most significant impact of climate change will be on water resources. There will be a severe problem with a water supply, and the situation of drought and flood will be created. The dry season will be longer in semi-arid regions, which will adversely affect the productivity of the crops. Uncertainty of rainfall will also affect the production of crops. Due to high temperature and lack of rainfall, more groundwater resources will be exploited for irrigation, due to which gradually the groundwater will go down so much that exploiting it will be economically unviable.

Depending on the variety, vegetable contains 70-90 percent of water. Proper irrigation is an essential part of vegetable cultivation; the lack of appropriate irrigation or over-irrigation could affect the quality of the product, directly affecting the postharvest cycle.

5.2.4 Impact of climate change on temperature and its effects on postharvest losses

IS92a, a scenario developed by Intergovernmental Panel on Climate Change (IPCC), predicted the GHGs and total radioactive force continue to increase through the simulation period of 1990-2100. CO₂ increases from 6GtC to 36GtC, CH₄ as 540-1170Tg per year, and NO_x as 14-19Tg per year. This scenario assumes a 2°C rise in global mean surface temperature between 1990-2100.²²¹

Department of Hydrology and Meteorology (DHM), Government of Nepal reveals that average temperature in Nepal is increasing at the rate of nearly 0.06°C/year between the period of 1977 and 1994. Another temperature analysis from 1976 to 2005 has revealed that the average temperature in Nepal has increased by 0.0597°C/year. The projected figures for Nepal further show that average increase in temperatures of 1.2°C for the year 2030, 1.7°C for 2050 and 3.0°C for 2100. IPCC, 2001b assessment report showed that the global mean surface air temperature has increased by 0.6±0.2°C over 20th century.²²²

Shrestha et al., 1999 and Gautam and Pokharel, 2010, showed that in Nepal the average temperature increase was recorded as 0.06°C/yr. and that in Terai and Himalayas was 0.04°C and 0.08°C/yr. respectively. This indicates that the warming rate in Himalayas is higher than in the lowland areas.

Climate change is frightening for both the present and the future, it is having a negative impact on the present and there is no doubt that its effects will be even more frightening in the future. Cyclones have appeared in the weather due to the change in temperature below sea level due to extreme heat. Increasing temperature affects crop growth due to changes in photosynthesis. On the other hand, the outbreak of insect disease will increase. Rising temperatures cause nutrients to change from organic to non-organic, and its growth increases plant evaporation, which increases the water demand of crops. Thus, along with the loss of natural resources, increasing temperature has directly and indirectly affected the crops, water and soil of the farmers.

²²¹Houghton, et al. (2001).

²²²Department of Hydrology and Meteorology (2017).

Agricultural practices are based entirely on weather. According to a report, rising temperatures are expected to reduce agricultural production in South Asian countries by 30 percent. For example, if the temperature rises by 1.5 degrees Celsius in Nepal, there will be less than one millimeter of rain and the production of vegetables will decrease by 3 to 15 percent. When the temperature rises, the glaciers melt and floods occur, burning out the fruits and vegetables. Agronomists believe that when ozone reaches 50 ppb, production will decrease by up to 30%.²²³

Rising temperature is another unavoidable problem for the postharvest practice. Temperature plays a major role to protect vegetables during transportation, storage and marketing stages.²²⁴ Most of the developing countries' refrigerator facilities are not available during transportation or even storage periods. In such a situation, the rising temperature is increasing the pressure on the farmers to save their vegetables from damage.²²⁵

Most vegetables are very sensitive to temperature, optimum temperature is required for the growth and development of vegetables, the optimum temperature being between the maximum and minimum temperature range. It is challenging to manage the temperature in the place because there is no cooling system or warehouse available in Nepal. Therefore, postharvest losses ratio is high due to climate change and rising temperature.

Table No. 5.1 Average temperature tolerance of vegetables

Vegetables	Maximum temperature (°C)
Brinjal, Chilies	35
Cucumber, Pumpkin, Zucchini, Squashes, Sweet Corn, Cauliflower, Broccoli, Capsicum	32
Carrots, Garlic, Leeks, Shallots, Spinach	30
Tomatoes	29
Beans, Beetroot	27
Garden Peas, Cow Peas, Turnip, Swede, Parsnip, Lettuce, Celery, Cabbage, Brussels Sprouts, Artichoke	24
Beans, Beetroot	27

²²³Feng, et al. (2022). pp. 47–56.

²²⁴Mercier, et al.(2017).

²²⁵Food and Agriculture Organization (2015). pp. 20-47.

Source: Maynard, D. N., & Hochmuth, G. J. (2006).

Vegetables	Minimum temperature (°C)
Cauliflower	0
Spinach, Beetroot, Brussels sprout, Parsnips, Turnips and Swedes	5
Artichokes, Cabbage, Carrots, Celery, Garlic, Leeks, Shallots, Lettuce, Peas	7
Pumpkin, Zucchini, Butter squash, Beans	10
Sweet corn	12
Cucumber	15
Tomato, Brinjal, Chilies, Capsicum	18

Source: Maynard, D. N., & Hochmuth, G. J. (2006).

5.2.5 Impact of drought on agriculture

Weather induced drought is based on the degree of drought compared to normal or average rainfall. Drought is the relationship between periods of low rainfall and surface water supply, not just a decrease in rainfall. Therefore, this reduction in rainfall results in depletion of surface and inter-surface water resources such as river, reservoir and groundwater, etc, Droughts usually occur by weather and agro-induced droughts, as reservoir and groundwater depletion are known only after a certain interval. Drought has a profound effect on agriculture production, irrigation, vegetable nutrition value, and other agricultural activities, etc.²²⁶

Due to the climate change drought has been increasing year by year which is directly affecting the irrigation facility for the vegetable production. Irrigation plays a major role to produce all kinds of fresh and healthy vegetables, vegetables and root crops that contain around 65-90 percent of the water in their postharvest life that is why Water contained in vegetables has a direct impact on the pre and postharvest losses.²²⁷

Irrigation systems have been mainly affected by the drought. Irrigation is the process of artificially irrigating for high yields.²²⁸ Nutrients and water play an important role in vegetable

²²⁶Food and Agriculture Organization (2015).

²²⁷Paltrinieri, G. (2015). pp. 5-7.

²²⁸Lebdi (2016).

production. About 80 percent or more of vegetables are made up of water. It is through water that the nutrients reach the whole plant. Vegetables are very sensitive to water scarcity, as most of the vegetables have low roots and complete plant growth and development in a short period of time. Even for a short period of time, lack of water adversely affects the production and quality of vegetables.²²⁹ Dehydration is most affected during the growth of vegetables, nutritional value, edibility, caloric value, acceptability or other intrinsic feature of the food.²³⁰ In many parts of Nepal where people are forced to grow vegetables behind rainwater, there is no doubt that drought will cause more damages. To prevent more damage from drought it is necessary to yield those vegetables which are tolerable to drought.

5.2.6 Monsoon

The Nepali summer monsoon is an integral part of the global climate system. Monsoon rains play a significant role in Nepal's agriculture, but climate change is hampering Nepali monsoon, scientists say, affecting food, agriculture, and the economy.

After comparing more than 20 climate models from around the world, the new analysis predicts heavy monsoon rains in Nepal. The monsoon season in Nepal is from June to September every year. Researchers at the Potsdam Institute for Climate Impact Research (PIK) have found strong evidence that monsoon rainfall increases by about five percent for each degree Celsius increase in temperature.

Monsoon creates many problems in agriculture, and people's lives are suffering from it. Due to heavy rains, hilly countries like Nepal are adversely affected.²³¹ Due to heavy rains in the hilly areas of Nepal, roads are blocked frequently for a few days or weeks. This increases the risk to damage of vegetables during transportation.

However, the risk of spoilage of vegetables in the middle of transportation is very high. For a few years, unseasonal rain is also increasing due to climate change, which badly affects vegetables during the harvesting or postharvest period.²³² Picking vegetables in the rain increases

²²⁹Khanom, et al.(2016). pp. 151-159.

²³⁰World bank (2011).

²³¹Malla, (2008). pp. 62-70.

²³²Mohajer, et al. (2015). pp. 1-12.

the chances of rotting as well. Some vegetables need to dry in the sun; in such cases, precipitation will cause the loss of the vegetable will increase.

5.3 Impact of climate change on disease and pests

Climate change often increases the risk of the growth of various insects. High temperatures and prolonged growing weather increase insects, pathogens, and nematodes as most insects adapt to hot and humid conditions. Insect outbreaks are often caused by seasonal conditions such as early or late rainfall, drought, or increased humidity, leading to increased disease and reduced yields. Insect infestations are more frequent, especially after prolonged drought and heavy rain, leading to reduced yields and even postharvest losses.

Climate change has a significant impact on the growth of pests and diseases. Temperature, humidity, and atmospheric gases will increase the reproduction of plants, fungi, and other bacteria and change the relationship between insects and their natural enemies. Hot air helps to increase the fertility of insects. In long-lasting spring, summer, and autumn, the reproductive numbers of many insects complete their life cycle. They hide the larvae somewhere in the winter. Changes in wind direction increase the growth of airborne insects as well as bacteria and fungi. More and more pesticides are being used to control these other diseases.²³³ In developing countries, where the marketing channels are not well managed in such a situation, it is highly possible to increase postharvest losses due to the pest and diseases at storage stage and during the supply chain.²³⁴

High economic losses due to many insect pests, diseases, nematodes, and mite outbreaks are significant obstacles to achieving the full potential of vegetable production. It is estimated that due to pest infestation in vegetables, there is a loss of up to 30-40 percent of the yield, due to which there is a loss of millions of rupees every year.²³⁵ To reduce the damage and control these pests, farmers generally spray chemical drugs indiscriminately, due to which chemical residues remain on the crop products and due to which there is significant harm to the environment and

²³³Food and Agriculture Organization (2021). pp. 22-36.

²³⁴Sanon, et al. (2018).pp. 2-7.

²³⁵Food and Agriculture Organization(2015).pp. 15-38.

health. To reduce the use of toxic drugs in vegetable crops, a lack of an integrated method for managing pest damage is often felt.

Climate change affects agriculture in different ways. Fertile soil, water, favorable environment, protection from pests and insects, etc., play an essential role in increasing the productivity of agriculture. Every crop needs proper temperature, the correct type of soil, rainfall, and humidity, and any change in these parameters affects the crop's yield and health, which could be one reason for the postharvest losses.

In addition to the above, the agricultural sector may be affected in many other ways due to climate change. Climate change affects soil processes and soil-water balance. When a soil-water imbalance occurs, dry soil becomes drier, which increases the demand for water for irrigation. Due to the impact of climate change on irrigation facilities, the risk of famine or flood causing severe damage to food crops has increased. Carbon dioxide levels have reached 450 ppm (per million) in 30-50 years. Increasing the amount of CO₂ is beneficial for some crops, such as wheat and paddy, in which the process of photosynthesis takes place through C₃, as it accelerates the process of photosynthesis and reduces the damage caused by evaporation. However, due to the temperature rise, the production of vegetable crops has come down significantly. Insects are the main challenge for the agriculture sector during pre- and post-harvest. It is hampering even more the farmers in developing countries; lack of proper knowledge and suitable infrastructure is one of the primary reasons for damaging products by insects. In Nepal, 10-20 percent of cereal grains are losses occurs due to the insect after harvest;²³⁶ it is estimated that vegetables are also in the same ratio.

In the present chapter entitled "Impact of climate change on diseases and pests," six vegetable crops are at high risk of pests, namely, Tomato, Cabbage, Eggplant, Okra, Hot Chili, Pumpkin, and Onion. Detailed information on insect identification and symptoms of damage is provided. This chapter also includes information on farmers' management practices in the field for various pests and diseases at different crop growth stages. This will help popularize the use of chemical

²³⁶Paneru, et al. (2018). pp-110-115.

pesticides required for significant problems, which will reduce unnecessary chemical sprays and also help protect against the natural enemies prevalent in vegetable crops. Pre-harvest diseases and insect infestations reduce the crop's shelf life and increase postharvest losses.²³⁷ Therefore, knowing pests and diseases at the farmer level and the appropriate prevention methods are necessary to control postharvest losses.

5.3.1 Tomatoes

Tomato is one of the most perishable vegetables, and it is difficult to control pests and diseases during and after harvest. Insects and diseases are more likely to be found in the summer season when temperatures continue to rise due to climate change for decades. Here are the main pests and diseases in tomato cultivation.

Major Insects on Tomatoes

Fruit borer: Due to fruit borer, there is a lot of damage to the yield of tomatoes. Its fully developed caterpillars are light yellowish-green in color with dark brownish segmented stripes on both sides. Young caterpillars feed on tender leaves while adult caterpillars penetrate through circular holes in the fruit and continue to eat the inner part of the fruit. A single caterpillar can eat 2 to 8 fruits and destroy up to 50 percent.²³⁸

Whitefly: Adults of this insect look like tiny white specks covered with white waxy flowers. The nectar and adult flies suck the sap from the underside of the leaves. The infected area turns yellow, and the leaves turn inward and eventually wither. Along with sucking the juice, these insects release sweet stool, which encourages the growth of mold and stops the development of the plant due to obstructing the process of photosynthesis.²³⁹

Aphid: Outbreaks of tomato aphids mainly occur in dry and cloudy weather. Cold conditions are conducive to its multiplication, while aphids' colonies are flooded by heavy rainfall. Insects on tomatoes usually fly from one field to another, especially from potato to tomato crop. Aphid sucks the sap from the lower surface of the leaf, which stops the plant's growth process.

²³⁷Habib, M. K., & Rizk, H. (2020).

²³⁸Singh, et al. (2021). pp. 53-63.

²³⁹Zhang, et al. (2022).

3.2 Some major disease of tomato

Early blight: The outbreak of early blight occurs when spring begins in humid weather immediately after planting. Affected plants have small black round spots on the leaf edges, which grow slowly. The outer edges of these dark spots are yellow tomatoes. Infected leaves wither, and marks fall off as they develop. Outbreaks appear to be exacerbated during this time. Outbreaks of leaf blight usually spread to the plant through the lower, older leaves. Insects on the leaves also cause sunburn on fruits.

Wet Rot: Initially, the symptoms of this disease are seen in some places in the nursery, but within 2-3 days, it spreads to the whole nursery and infects all the plants, and the plant suddenly withers and falls the ground and dies. Infected plants appear yellowish-brown in color with brown water-absorbing necrosis.

Bacterial spots: Water-soaked spots appear on the leaves with a greenish-yellow coating. Later, these spots appear gray and distorted. On ripe fruits, these spots appear from dark brown to dark brown when soaked in water and then cracked on these spots.

Late blight: Late blight disease occurs if humid conditions persist for a long time along with pleasant weather. Rapidly spreading disease causes severe economic damage. In this, gray-purple or black spots appear on any plant part. The spots on the leaves are irregular, slightly larger, greenish-black in color, and absorb water. These spots gradually turn gray and develop white fungus on the underside of the infected area on the lower surface of the leaf or the stem. Fruit stalks also become infected and turn black.

Buckeye rot: The first infection is immature; the lower fruits are near the soil and have yellowish-green circles (rings) visible in them. Later, these spots become gray and distorted. These spots are dark brown with black color and cracked on them on ripe fruits.

Foliar Crunch: This is a major tomato disease caused by whiteflies. The leaves of infected plants wither, and the plant's growth is stopped. The young leaves turn yellow and show signs of retreat. The edges of the old leave appear thick and curved inwards, and the size of the inter-joint is

remarkably small. Infected seedlings turn yellow, and in case of severe infection, the seedlings appear dwarf and bushy, and in this case, fruit productivity is negligible.

5.3.2 Cauliflower and broccoli

Major Insects on Cauliflower and Broccoli

Diamondback moth: Females lay single yellow eggs on the leaves. Caterpillars are pale green. Adults are small, light gray insects. There are three diamond-shaped pale yellow-white spots on both pairs of front wings, hence 'Diamond Page.' Newborn larvae eat leaf scraps by scraping, but mature larvae cut leaves and make holes. Cabbage is the favorite food of insects. Since the damage to cauliflower is indirect, there is more damage to the crop, mainly at the end of autumn.

Tobacco Insects: In the northern region, these insects cause more damage to cauliflower/cabbage crops grown during the rainy season. The front wing of the adult insect is gray and yellow with white striped edges. The baby larvae live in the herd. They turn the green matter of the leaves gray, and thus only the outer layer of the leaf remains, and the leaf looks reticulated. The developed larvae feed very quickly on the soft leaves and new plant parts. The larvae are dark gray to dark green with dark vertical stripes on both body sides.

Stem borer: Moths are light gray-gray. Adult females lay their eggs on old leaves or growing parts of plants. Caterpillars are gray and have 4 or 5 light pink-gray vertical stripes on their body. Caterpillars initially pierce the leaves and make them look like white paper filled with insect manure. Later, these caterpillars stick to the trunk and develop into many pieces. As a result, infected plants die, forming lateral shoots, and do not produce cabbage flowers. Insects entering the plant are covered with fiber and insect manure. It disappears when there is good rain. Its colonies are often found in soft shoots, and by sucking the sap from the fibers, the plant's growth is stopped, leading to poor-quality cabbage. In severe infections, the plant dries out completely. Cheap produce a honey-like substance, which has led to the development of legal integrated pest management strategies in the main crops of cauliflower/cauliflower seven vegetables, creating a black coating on infected plants. As a result, photosynthesis and plant growth are hindered.

Major disease of cauliflower and broccoli

Damping-off: This term describes the damage caused to seeds and emerging plants by various fungi in the nursery stage. Damage results in a reduced number of plants in the crop, and sometimes the damage is so severe that Re-sowing of the crop becomes inevitable. Its main symptom is the failure of seedlings, resulting in the rotting of seeds or plants or the sudden death of newly grown seedlings.

Milduromil fungus: This insect is found in cabbage and cauliflower. The higher the rainfall or dew, the more severe the damage to the crop. This disease usually occurs in the nursery stage of the crop, whereas its incidence is relatively more minor in the main field. The main symptom of this disease is purple-brown spots on the lower surface of the leaves. A whitish-gray, scaly growth usually appears on the lower surface of the leaf. Later on, the leaf becomes like paper and dries up.

Alternaria leaf spot disease: It is the most common fungal disease of cauliflower/cauliflower in the rainy season. Small and yellowish spots appear on the leaves. As these areas enlarge, annular circles are also formed with dark spots. In moist weather, this fungus causes light blue growth in the center of the above spots.

Bacterial black rot disease: This disease is more severe in cauliflower than in cabbage. Plants can get infected with this disease at any stage of crop growth. Infection can cause lower leaves of plants to drop and dry up. In developed plants, infection occurs through water spores at the core. The tissues turn yellow and the chlorosis progresses towards the center, causing a discolored “V” shaped pit on the leaf. Intensely infected leaves drop. Cabbage production is affected by the disease outbreak, and the cabbages of infected plants become smaller in size, and the quality decreases. If the infection occurs at a late stage of the crop, the cabbage also rots.

5.3.3Eggplant

Major insects of Eggplant

Bone beetle: Adult beetles are round, yellowish-brown, with many black spots. It has a pale-yellow waist and thorns all over its body. Their eggs are cigarette-shaped, pale yellow, and often

lay in clusters, and adults shatter leaf chlorophyll, feed on the green matter, and make the leaves very reticulate, and their shape resembles a ladder. Later the affected leaves dry out and fall off.

Leaf flower: Young adults are yellowish-green in color. Their characteristic is that they move diagonally concerning their body. They suck leaf sap on the underside of leaves. Infected leaves turn upwards and later turn yellow and wither due to insect infestation and stunted plant growth.

Sprouts and fruit borer: This is the most destructive insect in the eggplant crop. The moth has dark brown spots on its body, while its front wings have white spots. The larvae are pale pink. In the early stages, the larvae enter the seedlings, destroying the growth sites of the seedlings. Seedling withering and bending is an unusual symptom of an insect outbreak. The larvae enter the fruit through their horns. Therefore, there are no outward signs of insect attack on the fruit.

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5.3.4 Okra

Major insects of Okra

Leaf Blossom: This pest attacks at the early stage of the crop. Infants and adults of the leafhopper are yellowish-green with a pair of dark spots on the antrum and a black mark on the posterior side of each forelimb. These insects move diagonally in a unique way. Females lay their eggs in the nostrils of the leaves. Both the young and adults suck the sap from the underside of the leaves and release toxic substances into them. Infected leaves turn yellow and curl up at the edges. In severe infestation, the leaves turn dark red like a brick.

Shoot and fruit borer: The shoot and fruit borer outbreak usually occurs in moist conditions after rain. The larva pierces the top shoots of young plants, causing the nodes to die. After forming buds, flowers, and fruits, caterpillars enter them and eat their internal tissues. Infected buds and flowers drop from the plant. The entrance hole is closed by insect feces. Fruits lose their shape and have no market value.

Whitefly: Females lay a single egg with petiole, yellow and tufted, on the underside of the leaves. Babies are egg-like in shape and size and are attached to the surface of the leaves. Adults are small in size with light yellow physiques whose wings are covered with milky white waxy powder. Babies and adults usually suck the sap from the underside of the leaves and release a honey-like substance. Due to their infestation, the leaves appear sticky, covered with fungus. Plant growth stops. This insect also transmits the spot virus.

Chepa: Babies are light yellowish-green or greenish to black or light brown in color. Adults are primarily wingless, but feathers can be seen in some. Both forms produce direct offspring (parthenogenetically) instead of eggs, so their population proliferates. Cool and moist conditions are favorable for their multiplication, whereas they disappear with good rainfall. They suck their vital juices from the tissues, causing the leaves to curl. The leaves of plants appear shiny and sticky due to the honey-like substance released by the champas. Later, molds grow on this honey-like substance, and a black coating is formed on them.

Common diseases of Okra

Yellow vein scar disease: Yellow veins show a particular type of interrelated web-shaped symptoms that make up different areas of green tissue in the leaves. Later the whole leaf turns yellow. Plants stop growing, and their color turns yellowish-green. Most of the plants in the soil can get diseased, and at any stage of plant growth, the disease can start to spread. Infection prevents the growth of flowers and fruits, and they become small, yellow, and hard in size. The disease is transmitted by whiteflies and is economically the most important disease of a woman's finger. Sometimes it causes more than 80 percent damage to crops.

Powdery mildew: Powdery white spots appear on the lower surface of infected plant leaves, which spread to both the leaf's surface. At first white spots appear on the upper part of the leaves, but later, the whole surface is covered with white matter. Severely infected leaves turn yellow and wither. Acute infection can cause leaf blight and damage. The disease can cause most of the leaves to fall off the plant.

5.3.5 Onion

Common insects of Onion

Thrips: Thrips are the most severe pest of onions. Onions are grown all over the country. Insects are common there. Sometimes thrips infestation causes 50-60 percent damage to the bulb crops. Stains can be seen on all the small, white silver leaves. In affected plants, twisted leaf growth stops, and the plants die slowly.

Major diseases of Onion

Stamphyllum blight: This disease is most common in northern and eastern Nepal onion leaves. In winter crops, the severity of the disease is 5 to 50 percent. Infection occurs in late March and early April when small, yellow to orange spots or streaks develop on one side of the leaf or stalk. The spots often form large spots and cause the leaves to shrivel.

Sutradami: Usually infects young plants. As a result, the entire crop may be destroyed. Nematode infection causes abnormal inflammation of the roots, known as root knots or sores, which cause the plant to turn yellow, dry out, and interfere.

5.3.6 Pumpkin

Major insects of Pumpkin

Fly: This is a serious insect that has caused up to 80 percent damage to crops. Most damage occurs in July-August. Newborn insects enter the fruit pulp through holes and create a zigzag gallery, eating the fruit from inside, contaminating their feces and paving the way for the entry of cephalophytic fungi and bacteria. Due to which the fruit rots and becomes hollow and falls off before it is ripe.

Cucumber Insects: Larvae have white streaks on both sides of the body and are yellow to dark green in color. The larvae cling to the chlorophyll part of the leaves, collect them and trap them.

Red Pumpkin Beetle: This is a serious beetle. Adult beetles are responsible for damaging the plant above, mainly attacking leaves, flowers and fruits. They make holes in plants and fruits, causing the plant to die when it is not fully developed. The larvae live in the soil and feed on plant roots and stems.

White fly: Nymphs and adults mainly suck the sap and honey from the underside of the leaves, which develops black mold on the leaves, which reduces photosynthesis by the plants. In addition to the direct damage caused by their food, they also act as generators of viral diseases.

5. 3.7 Hot chilies

Common insects of Hot Chilies

Pesticide thrips: Thrips are small and slender insects that appear in nurseries and main farms and affect lifelong crops. Both adults and nymphs damage the crop, tear the leaf tissue, and suck the sap. Soft sprouts, buds, and flowers are attacked, causing the upper part of the leaves to twist and deform. Outbreaks appear to be exacerbated during the summer seasons.

Polyphagous insect pest: Adult Tobacco Caterpillar is brown. The second and third instar larvae make holes in the chili seeds, enter the chili pods, and take their food from the chili seeds. Affected pods dry out or turn white. They are habitually nocturnal but can also be seen during the day.

Vegetable production depends on the area's climate and the effects of various disease-carrying insects and viruses.²⁴⁰ However, due to a lack of necessary information, the crop has not been able to produce enough even though it has been cultivated well. For this, it is required to test the soil in time. In addition, by collecting information about the environment, rainfall, and various disease germs, the quality of disease-resistant seeds will be created, the crop will be protected, and the farmer will get a good yield. If the farmers can produce healthy vegetables, it will, of course, help to reduce postharvest loss.

Major diseases of hot chilies

Scratching: This is a functional disorder of the capsicum in which the fruits are affected by direct exposure to the sun. They form white necrotic patches, and the upper surface of the exposed sun is thin and dry, and paper-like.

5.4 Climate change adaptation strategies and techniques for vegetables farming

The destructive effects of climate change affect every aspect of our lives and will continue to happen. In an emerging country like Nepal, its challenges, especially for small farmers, are increasing daily. Rights to food, nutrition, food security, and food sovereignty are in jeopardy. To reduce or eliminate these changes, we must bring some changes in our ways so that human beings continue to exist on this earth.

²⁴⁰Skendžić, et al.(2021).

Assessing the effects of climate change requires many physical, biological, and socio-economic models, methods, and systematic information. Evaluation of current efforts and commitments to combat climate change makes it clear that we will not be able to achieve our goal of reducing greenhouse gases. In this case, adaptation is inevitable. It is strongly believed that the most important way to mitigate the effects of climate change on the path to sustainable development is to increase society's resilience. Some of the existing mitigation measures in agriculture may prove very important in the future. It is clear from the current efforts that progress in agriculture is possible only through coordination of climate policy, sustainable development, and improvement in environmental quality.

There are many measures to reduce the impact of climate change on Nepali agriculture, adopting which we can save our agriculture from the effects of climate change.

5.4.1 Farm water management

With the increase in temperature, there is a need for more crop irrigation. In such a situation, conserving the moisture in the soil, collecting rainwater, and using it for irrigation can be helpful and helpful steps. It can be used in the form of irrigation. While on the one hand, we will get the facility of irrigation; on the other hand, it will also help in groundwater recharge.

5.4.2 Organic and holistic farming

The use of chemical fertilizers and pesticides in the field, on the one hand, reduces the productivity of the soil; on the other hand, its quantity reaches the human body through the food chain, which causes many types of diseases. Chemical farming also increases greenhouse gas emissions. Therefore, we should focus more on organic farming techniques. Integrated farming should be done instead of single farming. Composite farming produces many crops so that if any disaster destroys one crop, the farmer can make a living from another crop.

5.4.3 Development of new technology in crop production

Seed varieties suitable for the new season and tolerant of high temperature, drought, and flood should be developed, considering climate change's profound, far-reaching effects.

5.4.4 Crop structure changes

We also need to change crop patterns and planting times along with climate change. The dangers of climate change can be addressed by intercropping.

In order to protect Nepali agriculture from the effects of climate change, we must use our resources wisely and apply our traditional knowledge while assimilating the Nepali way of life. We now need to emphasize such eco-friendly practices in agriculture to maintain our soil's productivity and save our natural resources

5.4.5 Tolerance crops

The observed drought pattern requires a variety of adaptive structures. For example, drought tolerant green gram, chickpea gram and Yellow Arhar Lentil can be cultivated in low rainfall conditions, which help in yielding 20-25% more than conventional seeds. Also, drought tolerant and early maturing Yellow Arhar Lentil (AKT-8811) and sorghum (CSH-14) can be suitable vegetable.

5.4.6 Water management

Water conservation technologies such as ferro-irrigation raised beds, small irrigation, rainwater harvesting structures, fertilizer measures, greenhouses, soil leveling; Wastewater reuse, reduced irrigation and drainage management can help farmers mitigate the effects of climate change.

Various techniques for estimating crop water requirement, ground water recharge technology, adoption of various scientific techniques in water conservation, change of fertilizer and irrigation time, cultivation of low yielding crops, planting period, change in irrigation, irrigation schedule and zero cultivation even in low rainfall and hot years. It can help farmers to produce satisfactorily.

5.4.7 Crop rotation

Growing the same crop in the same place every year can cause pests and diseases. These will be transferred from one crop to another. Crops should be planted in different lands every year and will not return to their original place. A minimum cycle of 3 to 4 years is generally recommended for vegetables. Crop rotation helps different types of natural predators survive on the farm. The normal four-year cycle includes the following:

First-year nuts

Second-year grain

Third-year root crops

Fourth-year green manure or weeding

5.5 Conclusion and suggestion

Agriculture is the cornerstone of Nepal's economy. The most adverse effect of agriculture and climate change is falling on the poor farmer. Due to the difference in the amount of rainfall, the quality of the product has also been adversely affected. The poor-quality leads to losses during the supply chain. In many parts of the country, crops dry up due to scanty rains or are washed away by excessive rains, reducing food grain. It is challenging to grow a healthy product even if it is subsidized. Soil moisture and productivity have been affected by the rise in temperature.

Climate change has caused severe water supply problems and increased the frequency of droughts and floods. Irrigation is very essential to produce healthy vegetables, over irrigate and under irrigate could lead to disease attacks quickly this also one of the reasons of postharvest losses. Nepal is an agricultural country and is most at risk from all causes of climate change on postharvest losses. Rising global temperatures are causing unpredictable changes in the climate, threatening the agricultural sector and the postharvest losses.

Climate change can reduce agricultural economy up to 25 percent its effects even more in postharvest losses.²⁴¹ Therefore, it is time to realize the importance of climate resistant agriculture and implement it more strictly. Adopting appropriate mitigation techniques, such as cultivating breeds that can tolerate climate stress; Water and nutrient management for efficient productivity and resource utilization; Agricultural advice for timely crop monitoring; In order to address climate change and achieve sustainable development goals in Nepal, agricultural practices are important for conservation of soil organic carbon and plant growth, compost management and creation of favorable environment.

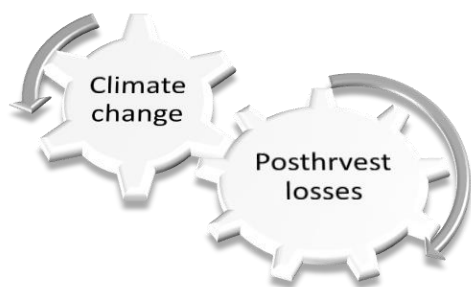
²⁴¹Bera, S. (2018).

Various postharvest techniques can also be adopted to reduce losses in the process of pre-harvesting, harvesting, freezing, temporary storage, transportation, handling, and market distribution. In recent years, researchers have developed digital mediums to monitor, optimize, and transform management, logistics, and post-crop supply chain processes to improve quality and reduce postharvest losses.

Climate change's immediate and far-reaching effects on agriculture need to be studied. There is no shortage of agronomists, but agronomists have not been able to accept climate change. Therefore, research in this direction has not started. There are two things to do immediately in this area. One is to understand how climate change is changing the agricultural cycle, and the other is whether we can make up for it by growing more alternative crops. At the same time, it is necessary to develop crops that can cope with the risks of climate change, such as developing varieties that can withstand high temperatures and low or low rainfall.

Given the severe and widespread impact of climate change considering the profound and far-reaching effects, such varieties of seeds have to be developed suitable for the new climate. Such combinations will have to be created, capable of tolerating the hazard of high temperature and drought, floods and can also tolerate salinity and alkalinity. Along with climate change, we also have to change the format of crops and the time of their sowing. To save Nepali agriculture, we have to use our resources judiciously. Such eco-friendly methods will have to be given importance in farming to maintain our land's productivity and save natural resources.

The effects of climate change on soil, crops, insects, diseases, and water resources and the damage caused by climate change are being discussed worldwide. Despite this, no exact solution has been found to the damage caused to agriculture, the most significant impact in postharvest losses, where farming is traditionally practiced. Many crops grown without chemical fertilizers have been destroyed and replaced by new crops. This requires large quantities of chemical fertilizers, pesticides, refined seeds, and irrigation. This has directly impacted the living standards of the rural farming community. Farmers have been forced to take up other occupations due to losses in agriculture.



On the one hand, production in agriculture has declined, but the cost has increased many times, and there is a surplus crisis. Changes in the summer, cold and rainy seasons have made it difficult to safely deliver the products to the market, leading to increasing postharvest losses. Lack of electricity makes it difficult for farmers to store their produced vegetables; no cooling facility is the main reason for postharvest losses. As a result, our

agricultural nation falls prey to hunger, poverty, and unemployment.

The structure and quality of Nepali soil are favorable for agriculture, but climate change is affecting soil quality, humidity, and productivity. On the one hand, excessive use of chemical elements affects its quality. At the same time, the problem of soil erosion is increasing due to floods and landslides. Drought is making the land barren. This is all a result of climate change. This increases the risk of rapid spoilage of the produced vegetables and directly affects postharvest losses.

Due to continuous increases in temperature and climate changes, crops are getting damaged; on the other hand, this type of environment is favorable for insects. Due to this, their fertility increases. Insects cause significant crop damage and are one of the biggest reasons for postharvest losses. To control this, excessive use of pesticides is required, which can lead to many diseases in humans and animals. These pesticides are mixing with rainwater and poisoning rivers and ponds, polluting the whole of nature. The environment directly impacts postharvest losses, and the environment is also directly affected by postharvest losses.

The state of climate change cannot be completely reversed, but its effects can be mitigated by taking appropriate measures.²⁴²Farmers can be brought out of the current deficit situation and

²⁴²National Aeronautics and Space Administration (2015).

brought into profit. The government, agriculture department, and farmers should work together. Therefore, conservation of soil moisture and collecting rainwater for irrigation can be a helpful, collaborative step to avoid over-exploitation of groundwater resources due to high temperature and lack of rainfall. This will help in both irrigation facilities and groundwater recharge. It will also provide great relief in case of floods and can prevent soil erosion. Agriculture will also be possible in areas that have become barren due to drought. In warmer climates, an increase in insect reproduction can be achieved with organic neem paste. Organic management does not adversely affect human life. The government, the administration, the general public, and the industrial houses should think in this direction and stop the atrocities against nature. Creating a clean and healthy environment can save our planet from terrible problems like climate change.

All around the world massive amounts of losses after harvesting vegetables are incurred during transportation and distribution. Vegetables are estimated to be destroyed between one-third of farms and roads and another one-third between road heads and consumer level.²⁴³ Postharvest losses during transportation are increasing due to the rigging temperature. Nepal's transportation network of perishable goods like vegetables is very poor. The concept of refrigerated transport for vegetables is yet to be developed. Its importance is even more significant in a geographically diversified country like Nepal. The inability to deliver the vegetables to the market at the expected time is due to more landslides and other natural calamities, and the rising temperature is increasing the postharvest loss of vegetables in transportation. This decline in transit is complicated by inadequate and rough packing. In such a situation, an effective and, at the same time, affordable transit network should be provided in the potential vegetable growing area. Rail transport is 8-10 times more efficient than road transport in terms of energy use to carry the same cargo. But unfortunately, due to the non-operation of rail transport in our country, long-distance transportation of vegetables is done by road. Therefore, it is necessary to modify long-distance transport by improving refrigeration, massive ventilation, and fast loading and unloading systems. It is found that post-harvest production losses occur during transportation and distribution.

The study concludes that there are significant factors of postharvest losses due to climate change, but No one seems to have paid attention to this. To avoid its adverse effects, it is essential to

²⁴³The High Level Panel of Experts (2014). pp. 39-50.

make the farmers aware. High temperature-resistant vegetables are essential to prevent losses due to climate change and rising temperatures. Establishment of greenhouse vegetable production, cold storage, and storage facilities at the farmer, wholesaler, and retailer level; Imparting training on pest diseases at the level of farmers, wholesalers, and retailers; Along with this, the damage caused by climate change can be reduced by modernizing transport vehicles and installing cooling facilities, etc.

Chapter 6 Summary and conclusion (164-177)

6.1 Introduction

Vegetables have immense importance for human beings. Their nutritional properties and taste help keep humans healthy. In the present scenario, the last few decades have increased the possibilities of vegetable products manifold, but the losses due to poor postharvest management have also increased. In horticultural produce, where loss or damage begins, the main site is the plant, and then there is considerable damage at harvesting, handling, and storing of the product. These losses can be reduced by pre-harvest and postharvest treatments and postharvest management.

The main objective of this study was to find out the genuine causes of postharvest losses and find solutions that can be of real benefit in the context of Nepal. Based on the data collected from the survey, this study has concluded that there is a massive loss of vegetables in areas where it should not happen in both Nepal and Japan. In both countries, losses on the farmer side are high compared to others, but the reason for the losses is different. In Nepal, the reason for losses on the farmer's side is also the reason for losses on the wholesaler and retailers' side. Nepalese farmers do not harvest crops carefully, which leads to poor-quality of vegetables, affecting the entire distribution system.

About 20 to 30 percent of fruits and vegetables are lost due to improper handling, transportation, storage, and marketing of fruits and vegetables. It is necessary to manage postharvest to compensate for this loss. About 20-25% of fresh fruits and vegetables are compressed and populated, reducing their market value and consumer acceptance. By reducing the area of this loss, its supply can be increased without additional arable land. This area of loss can be reduced

by increasing its supply area without cultivating or cultivating additional land, due to which pollution is also under control.

Nearly 70 percent of Nepalese have directly entered agricultural farming; apart from this limited arable land and limited sources, postharvest losses are a significant challenge for Nepalese farmers. Recognize this problem; this study was undertaken to find the actual causes of postharvest losses and find suitable solutions.

The study was completed with primary and secondary data, and the survey was conducted in different villages and districts of Nepal and different prefectures of Japan. Japanese agricultural practices and supply chains are highly developed and well-known worldwide. The survey found that postharvest losses at the farmer level and supply chain are low compared to Nepal and other developing countries.

From that perspective, Nepali farmers could learn from Japan's economic growth and agricultural development. The results of some research on distribution channel systems, harvesting methods and equipment in different parts of Nepal, the situation of small farmers in Japan, and how they harvest their produce show that the methods used in Nepal are similar to those in Japan 80 years ago. So Nepal could emulate modern Japanese equipment and technology, and it could be the backbone support for agriculture and be the right formula for reducing postharvest losses. It can contribute to Nepal's agricultural development by adding various analytical tools learned in Japan to the advanced agricultural technology and knowledge that the study found.

6.2 Summary and finding of research

The first chapter presents a series of research topics, covering the whole landscape of the Nepalese farming system and the support received from the Government of Nepal and related agencies. This chapter covers the need for a thesis and how this study can help Nepali agriculture reduce postharvest losses.

The second chapter (Postharvest practice and losses of vegetables in Nepal) covers the state of Nepali vegetable farming, its scope, and challenges. Questionnaires were surveyed by studying in different places in Nepal, including Himalai, Terai, and Pahadi (hilly) districts means the

study is trying to cover the country; this study finds that postharvest losses are highly occurring all over the vegetable supply chain and losses on farming sites are relatively high. The reason for the postharvest losses in the farmer site is the lack of proper knowledge about harvesting methods and practices after harvest. Pre-harvest activities also lead to postharvest losses, such as if the farmers cannot produce healthy vegetables, they could spoil quickly and can be the reason for quick infection during the supply chain. So, the study suggests that harvesting methods and farming methods should be changed and modernized to control postharvest losses. Pre-harvest activities include irrigation, planting time, seed selection, selection of vegetables according to weather and location, etc. The lack of appropriate transportation and storage facilities is another major cause of postharvest losses in Nepal. The transportation losses could also be controlled from the farmer's side. 20-35% of produce is wasted due to a lack of proper postharvest management and inadequate packaging.²⁴⁴ Same is the case with Nepal as mentioned by Sharma, et al. (2022). The survey showed that packaging materials and methods are inferior at the farmer level. Sometimes they want to avoid buying packing material, resulting in high losses during transportation and storage. But in the case of Japan, they pay careful attention to packaging, material, and technology is also advanced, so losses during transportation are found to be very low.

In the absence of storage facilities, farmers are forced to sell vegetables as much as possible after harvesting or when it is time to harvest, which is also one reason for postharvest losses. They want to avoid pre-cooling, cleaning or disinfection, sorting, grading, etc. Also, there are no cooling facilities entire the supply chain. Farmers cannot build a storage hall with cooling facilities due to a lack of funds; the concerned sector of the government should pay attention to this. This can help postharvest loss, and Nepali products can meet the market demand. Recently Nepali farmers have been unable to fulfill vegetable demand; Indian vegetables cover more than 50 percent of the vegetable market. This doesn't mean that there are not enough cultivated vegetables in Nepal. Still, the reason is a lack of the proper market channel, storage facilities, and transportation is not well managed, So Nepali vegetables cannot compete with Indian vegetables. Intermediaries have a big hand in the management of the Nepali market. For some commissions

²⁴⁴Sharma, et al (2022).

from the Indian market, they set up various barriers in the Nepali market channel. So frequent government strictly observation is also needed. The Japanese market is well managed in terms of channels, so the cooling process occurs at JA Group.

The third chapter (postharvest practices and food losses in Japan) was conducted on farmers, wholesalers, and retailers in the different prefectures in Japan. Studies have found that Japanese farmers are well-educated about farming methods, diseases, and pests. Retailers and wholesalers know food loss and vegetable supply chains, packaging methods and materials, storage, etc. The supply chain is highly developed, temperature control systems have been installed in transport vehicles, and good human resources during loading and unloading help maintain the quality of vegetables and help reduce postharvest losses. The agricultural environment in Japan is well-organized, and everyone is doing their part. But the study found that the loss on the part of the farmer during the selection process is very high. Loss during selection processing was found to be 3.0 percent, higher than the harvesting, packaging, and loading and unloading process. This can be controlled by selling at a low price or using it as raw material for functional food.

In almost all developed countries, postharvest losses in close to farm are relatively low,²⁴⁵ but in the case of Japan, it is slightly different. The postharvest losses are more at the farmer level than in the distribution system. The reason for this is the choice of Japanese consumers when purchasing vegetables. Because Japanese consumers care about the quality of vegetables and the size and type of vegetables, it is difficult to sell and distribute vegetables of odd sizes, which leads to the loss of vegetables at the farmer level.

This problem is not a big challenge for developed countries like Japan. Unmatched size vegetables can be used as a raw material for functional food. If the unmatched and odd size vegetables could be used as a raw material for functional food, the postharvest losses on the farmer's side would be reduced by 50 percent.

At the part of food losses, in most developed countries, people see the food loss only as an economic loss. Food loss is not only financial loss; there are enrolled natural resources and

²⁴⁵Hodges, et al. (2011). pp. 37-45.

human efforts; of course, the economic sector also lost with it. Postharvest losses are one of the characteristics of food loss, but generally, we see food loss occur at the consumer level, like the house, restaurant, party hall, etc. Generally, food loss occurs at the time of harvest, distribution channel, and consumer level; in developing countries, most of the food loss occurs at the farm-to-consumer level, but in developed countries, the food loss occurs mainly at the consumer level.

The cause of food loss in developed countries is almost the same, but in the case of Japan, Japanese food varieties are also a cause of food loss. In Japan, many types of food are used for raw fish and meat, such as sushi (寿司), sashimi (刺身), etc. The expiration date of that food is relatively very low than other foods, so if those types of food are unsold or unconsumed in time, food will expire and be lost.

The conclusion of this chapter is to reduce postharvest losses should be started from the farmer's side; if farmers produce healthy vegetables and follow all the postharvest activities, it is possible to minimize losses in the entire distribution channel. To bring less postharvest losses in Japan, all members are palpable, but credit especially goes to farmers.

The fourth chapter is (Postharvest losses of tomatoes in Nepal). Tomato is known to be highly perishable among vegetable items. Tomatoes can be cultivated all year round. Tomato is an important vegetable crop in terms of production and nutritional value. The taste of vegetables is incomplete without tomatoes. In Nepal, many farmers only cultivate tomatoes all over the year.

Similarly, the loss on the part of the farmers was relatively higher as compared to the suppliers and retailers. The reason for higher losses on the farmer side is the harvesting method, rough handling during harvesting, and packaging. Tomato is highly perishable among vegetables, so harvesting and packaging play a significant role in all distribution channels. Proper packaging is vital in reducing blurring and crushing and improving product marketing. Also, it helps minimize moisture, prevent product contamination by spoilage organisms, and maintain a hygienic environment during marketing. But the survey found that farmers did not use any scientific method during harvesting and packaging.

The harvesting stage is also essential to prevent losses, but most farmers were unaware of the proper harvesting time for tomatoes.

The study found that postharvest losses for other vegetables and tomatoes were slightly different; tomatoes being a perishable commodity, lack of proper handling system, and knowledge about insects and diseases is a significant reason for the postharvest losses of tomatoes. Due to the lack of adequate storage facilities in Nepal, farmers, retailers, and wholesalers could not preserve the produce. Also, Nepalese tomatoes have to compete with Indian tomatoes, so sometimes Indian tomatoes are much cheaper than Nepali tomatoes. In this situation, consumers buy Indian tomatoes. In the absence of safe storage facilities, unsold tomatoes are compelled to be sold at low prices; otherwise, the vendors are forced to throw away the unsold tomatoes. If retailers cannot sell tomatoes in the market, wholesalers and farmers will be affected, and postharvest losses will increase. Therefore, farmers should be educated about their profession to perform the harvesting process well.

The chapter Five (Climate change and its impact on postharvest loss). Superficially, we cannot find a link between postharvest losses and climate change, but on closer inspection, postharvest losses and climate change are interrelated. The impact of climate change is higher in developing countries than in developed ones. Developed countries have the resources to cope with climate change, but in most underdeveloped countries, farmers' agricultural occupations depend on the weather and climate. For example, Japan, a developed country, has a cold chain system that helps control temperature and prevents damage. But if we look at Nepal, a developing country, such methods and technologies have yet to be developed, which is why the damage caused by temperature is increasing.

In addition, climate change is increasing postharvest losses due to extreme rains and droughts due to countries' food and geographical diversity, such as landslides. When the road gets jammed and the traffic comes to a standstill during the rainy season, such a serious incident occurs, increasing the loss during transportation. In order to prevent such losses, transport vehicles containing refrigerators should be practiced, which will help reduce losses when landslides or floods block roads. Due to rising temperatures, many new diseases and insects are being

originated. In such a situation, it is challenging to protect vegetables during storage, so losses can be controlled by installing cooling machines in warehouses.

In Nepalese agriculture, the relationship between postharvest losses and climate change is not given much importance. However, postharvest losses due to climate change have been more significant than other factors. Due to climate change, disease and insects are spearing in vegetables. Farmers are unaware of those pests and diseases; in such cases, an ampoule number of vegetables is lost before and after harvest. Due to climate change, temperatures are rising, and Nepal does not have a proper distribution system and cold storage facilities. In such a situation, there is an unfortunate situation at the distribution channel and market level, and there have been enormous postharvest losses.

In response to the question of how much knowledge the farmers have about their agricultural profession, the survey concluded that Nepalese farmers are still ignorant about their produce (vegetables); they have no knowledge about pests, harvest time, and how vital the harvest stage is for damage control.

Nepali farmers are still using traditional methods during harvesting and other activities after the harvesting process. which needs to be changed, and modern techniques, equipment and technology, can be applied such as the methods used in developed countries like Japan can be used among Nepali farmers as well, thus helping to reduce the losses.

How do the farmers reach the market, how do the traders find the producers, and where is the postharvest loss? The study has shown that the most significant loss occurs on the farmers' part. In addition, this study has also demonstrated that Nepali farmers have to bear the brunt of the lack of market management. To solve this question, the market channel must be organized; for this, the farmers could collect the vegetables in one place and take them to the market. By doing this, the problem of price fluctuation at the time of sale can also be solved.

The government of Nepal has been making significant investments in the agricultural sector every year, but how much have the farmers benefited from the government's agricultural subsidies? In answer to the question, this study has found out the consequences of the

government grant among Nepalese farmers. The government subsidy is corrupt midway and does not reach the farmers. The monitoring of the government is necessary to control misuse.

This study has concluded that climate change and rising temperature are significant problems of postharvest losses of vegetables in Nepal, especially during transportation and storage. Some other climate change issues, such as floods and landslides, are indirect causes of postharvest losses during transport.

A survey in Nepal and Japan study found a massive difference in harvesting methods, tools, and education levels of farmers, wholesalers, and retailers, as well as the supply channel system.

A survey in Nepal and Japan study found a massive difference in harvesting methods, tools, and education levels of farmers, wholesalers, and retailers, as well as the supply channel system. Introducing those methods and tools could reduce postharvest losses; for this, it is necessary to give training at the farmer's level. For this, farmers, distributors, and retailers must be aware.

In developing countries, postharvest losses occur due to a lack of education on farming methods, transportation, storage systems, irrigation, unregulated supply chains, or lack of market facilities. It is estimated that vegetable spoilage occurs between one-third between farm and road-head and one-third between road-head and consumer. Nepalese transport networks for perishable goods such as vegetables are very poor. The concept of refrigerator transport for vegetables is yet to be developed. This drop-in transit is compounded by insufficient as well as poor packing. In this situation efficient and, at the same time, cost-effective transit network should be provided in the potential vegetable growing areas. Rail transport is 8-10 times more efficient than road transport in terms of vibrating vegetables during transportation to move the same cargo. But unfortunately, the long-distance transportation of vegetables is mainly by road as rail transport has not yet been proved in Nepal. Therefore, it becomes necessary to modify long-distance transport haulage by improving refrigeration, more excellent ventilation, and quicker loading and unloading systems. Defects in the vegetable marketing system it becomes very difficult to ship the perishable product to distant market terminals. It is found that most of the postharvest losses in yield occur in farms and distribution. Here significant weaknesses in farmer and distribution levels are as follows.

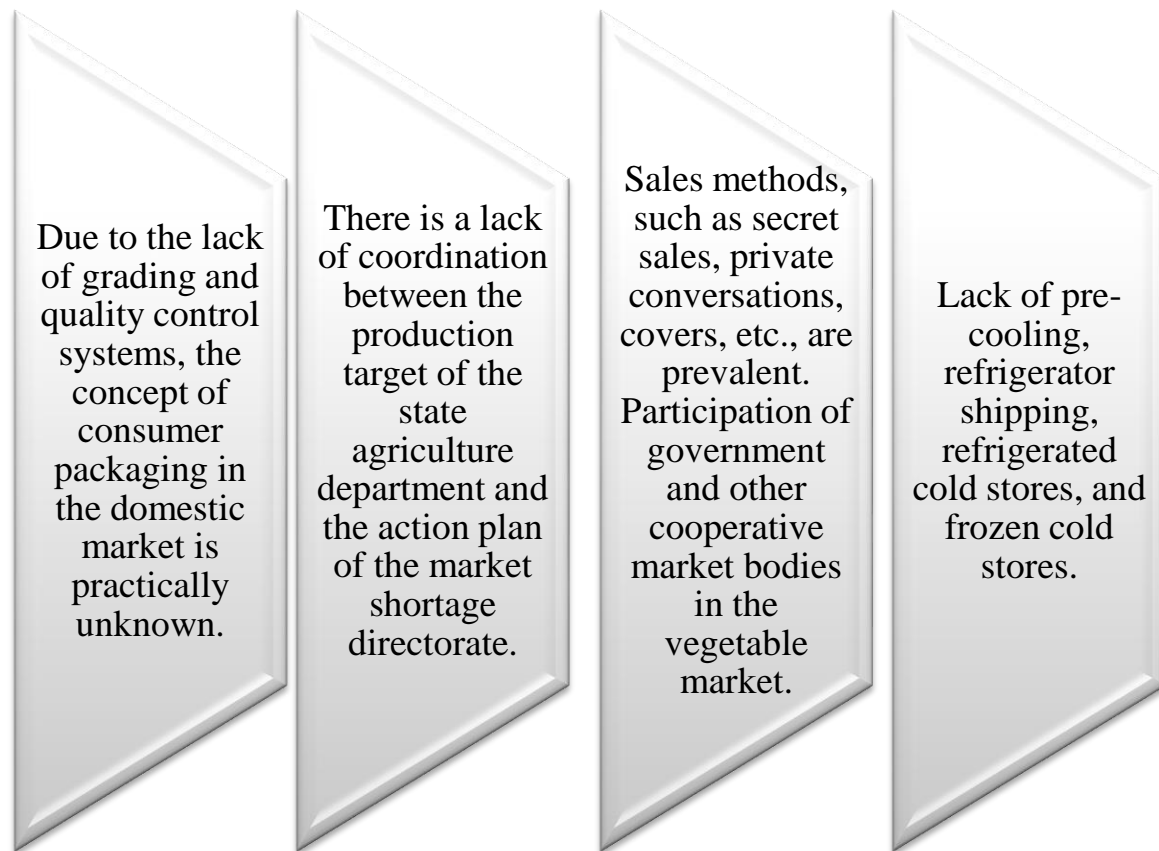


Figure: 6.1 Notable weaknesses in farmer and distribution levels, Source: By authors

In economics, demand and supply are excellent models for understanding the price of goods sold in the market. It depends on a high degree of competition between buyers and sellers. If there are more buyers, then they bid against each other and thus increase the price because the demand for the good is high and the supply is less; on the other hand, if there are more sellers or the supply is more, then they bid against each other and thus the price is reduced. The balance is the point at which all bidding has been made; No one has any incentive to offer higher prices or accept lower prices. This type of market settlement is a required must in Nepal. This helps in reducing the losses due to the lack of market.

After packing, the product goes for sale in the market. Currently, vegetables are being transported in huge quantities by loading them in rickshaws, carts, jeeps, and trucks, due to which huge losses are caused during transportation. But now the growers are not paying attention to it, and fridge vans are also unavailable to transport fresh vegetables. The use of cooling chain

vehicles for long-distance transportation, fridge vans, or long-distance and near markers needs to attract the attention of the related agencies. Basket/rack stacking is one of the few factors that can reduce traffic jams. There is an excellent need for government support to set up an entire chain facility for agriculture production.

After harvesting vegetables from the field, it is necessary to store the product until it reaches the market. Therefore, it is essential to avoid spoilage of the product and extend its shelf life. The temperature and relative humidity of the storage house are the main factors that affect the stored product's respiration and evaporation. Both of these processes can be detrimental to yield. Sustainability is essential for the storage of vegetable crops and temperature relative humidity management. New technologies are available, which make it possible to achieve an optimal environment in insulated stores. It is necessary to provide modern storage facilities to Nepali farmers. As a developed country, Japan's storage and distribution technology are world-renowned. If Japanese technology, storage, and distribution can be introduced in Nepal, it will help work the postharvest losses in Nepal's agricultural sector.

The importance of packaging is not found in the Nepali agricultural market. To save on the cost of packaging, it is customary in Nepal not to do packaging, and even if it is done, not proper packaging is done. Most farmers are unaware of the enormous loss incurred due to spoilage of products while trying to save on the minimal cost of packaging. In Nepal, where there are potholed roads and transport vehicles are not in good condition, food packaging can reduce the loss in the entire supply chain, and for that, it is necessary to raise awareness among the farmers.

Packaging is transporting, distributing, storing, and preparing goods for retail and presenting them to the consumer in the most attractive way. Packaging ensures safe product delivery to the end-user in the best condition at the lowest cost. Packing should be appropriate to protect the product during handling and transportation. Choosing a suitable packing material is very important. Selection should be based on production, transportation, market distance, or storage period. Bamboo baskets and jute bags are used for transportation in the local market.

Vegetables are very perishable, so they must be protected from mechanical injuries. Scratches, cracks, cuts, breaks, and damage during harvesting can be a part of pathogen entry and dust

accumulation, which affects appearance and spoils quickly. People involved in harvesting must be appropriately trained and skilled in handling fresh produce. But the farmers in Nepal are not that skilled. They also do not care about harvesting skills, which affects product quality and harvest losses.

Since vegetables are fragile and perishable, they can spoil quickly and lose value if not managed. To avoid damage and maintain the quality of vegetables, it is necessary to work them correctly from the time of harvest to the time of reaching the consumer. The postharvest life of vegetables depends on the decision of maturity, proper crop conditions, and careful care of the produce. They harvest immature or overripe vegetables resulting in reduced quality and rapid spoilage. Improperly harvested vegetables can affect quality, color, and taste and can be discarded quickly. Therefore, the maturity indices should be observed, and the right crop should be harvested at the right stage. Postharvest technology works on the principle of "saving means of production." Proper management of harvested produce minimizes postharvest losses. This makes crop production more nutritious and acceptable through processing and consolidation. Maintenance of crop production involves various factors such as pre-cooling, washing, curing, packaging, storage, and careful transportation. These postharvest factors affect the shelf life and market value of vegetables. But the survey found that Nepali farmers are not facilitated by advanced farming equipment. Also, available tools are not used well. Therefore, farmers need the knowledge to harvest vegetables, get maximum returns from their produce and prevent postharvest losses.

The disease is a successful interaction between a viral pathogen and a sensitive host under favorable conditions. Fungi, bacteria, and viruses cause diseases. Disease-causing organisms are called pathogens. Pathogens can be transmitted from the soil, carried by seeds, or spread by air and water. Insect vectors transmit some viral diseases. Some of the major diseases of the vegetable crop are anthracnose, wilt, bacterial spot, and bacterial blight, dumping off, early blight, fusarium blight, late blight, leaf curl, mosaic, powdery mildew, rot and septal leaf blight, small leaf, leaf curl, Bacterial canker, buck eye rot, fruit rot, etc. Due to the disease, the vegetable traders have to bear the loss of a large quantity of vegetables before and after the harvest. Moreover, farmers of underdeveloped countries like Nepal are more affected. Due to a

lack of knowledge about the disease and how to prevent it, large quantities of vegetables are being lost in Nepal.

Vegetables are relatively more susceptible to insects such as worms, nematodes, and mites. The use of fungicides and insecticides in vegetables for disease control is increasing due to intensive farming and expanding cultivation into new areas and seasons outside the scope of traditional crops. Pesticides are synthetic compounds and are harmful to the environment. Indiscriminate and improper use of pesticides leads to the extinction of beneficial insects and strains, leading to insect-resistant species and ecological imbalance. The increasing use of pesticides is a significant factor in the rising incidence of pesticide residues in vegetables. Since farmers in Nepal are not very conscious of the disease and the medicine for its control, most farmers use the same medication for all kinds of conditions, so instead of controlling the disease, more damage is done to the vegetables. So, the study finds that several responsible factors for the postharvest loss of vegetables in Nepal are relatively high in farmer sites. It can reduce postharvest losses by assisting concerned sectors.

The study concludes that the farmer side is more responsible for the postharvest losses from their pre- and postharvest activities. To reduce postharvest losses, first, attention should be paid to educating the farmers about their cultivation, harvesting, packaging, etc., which will be the backbone support to control postharvest losses. A survey found that most farmers were in primary-level education and were unaware of modern tools and technology. Even they are not informed about technologies used in developed countries during harvesting and after-harvest activities. Due to the lack of education, innovation of modern tools is also impossible, so Nepal's education board should include an agricultural syllabus from the primary level, which will help new generations and also helps to modernize agriculture sector. To control postharvest losses, the first step is farmer level, so Nepali farmers need to train in information about harvesting tools, methods, the importance of packaging, gardening, cooling, sorting, etc. It will help to control their losses even, and this will help prevent losses on the wholesaler and retailer side.

Preharvest activities also responsible for postharvest losses such as irrigations.²⁴⁶ Well-organized water management plan and irrigation timing is the key to water management in vegetable crop production. Leafy vegetables require constant irrigation. Fruit, root, and tuber vegetables have different vital stages of water requirements. Knowing about the water-sensitive stages of vegetable crops is essential. Most of the agriculture in Nepal's hilly areas depends on rainfall for irrigation, in which case the timing and amount of precipitation have declined for over a decade due to climate change. Lack of proper irrigation production is reducing, and even produced vegetables are also infected by disease and insects; due to this, it is challenging to protect vegetables pre and postharvest. Although irrigation facilities are available in other areas, vegetable farmers do not know much about the importance of irrigation. It is imperative to know the time of irrigation, the proportion of irrigation according to the vegetables, etc., as well as the variation of irrigation according to the season. From this, it can also be concluded that the level of education is not in favor of the farmers, and it has also been found that pre-harvest activities cause postharvest losses.

Agriculture is considered the basis of our economy. Nepal's agriculture contributes about 25 percent to the country's gross domestic product (GDP), provides significant employment, and meets the nation's food and nutrition needs. It provides essential raw materials to some industries. Due to the rapidly changing business environment, the pace of technological change, globalization, the competitive environment, and the changing role of government, Nepali agriculture is facing many challenges. Today, agriculture has gained commercial importance. It must change from the livelihood industry to the business-oriented, from import-oriented to export-oriented, supply-oriented technology to demand-oriented technology. Every day new investments and new technologies are hitting the world market. If these technologies can be brought to Nepali farmers, there is a possibility of a radical change in Nepali agriculture. The demand for processed and packaged foods is growing daily, so there is a great need for a trained workforce in this business. Many businesses in and around the agricultural sector are slowly flourishing. As a result, the development of agribusiness is likely to move forward. Agribusiness management has recently become a popular career choice for Nepali students. There is a great

²⁴⁶ETEFA, et al.(2022). pp. 1-10.

need to support the development of professional agribusiness colleges and institutions that can meet the management requirements of a changing agricultural landscape and ensure the future of Nepali agriculture. Agribusiness education is a qualification that helps farmers transform into good professionals with managerial expertise. Nepal's agricultural sector can be radically changed by providing proper education on commercial agriculture to Nepal's farmers, which will also help reduce postharvest losses.

In a developing country like Nepal, the agricultural system with advanced and backward links includes the following four areas. Such as agriculture, investment, production, marketing, and distribution sector. These four areas act as interconnected parts of the system in which the success of each site largely depends on the appropriate functioning of the other areas. Thus, agribusiness is related to successful business operations in food and agriculture.

To commercialize agriculture, it is necessary to expand specific products, postharvest management (harvesting, packaging, processing, transportation, and distribution), and establish the product in the domestic and international market. Due to improper managing, deterioration, floods, droughts, pests and diseases, and lack of knowledge of postharvest technology, 20 to 30 percent of crops are destroyed yearly. In the case of fruits and vegetables, the waste is about 25 to 50 percent. In the agriculture sector, many agri-business activities such as agri-investment integration, agro-production, agro-processing, and agri-marketing and trade come under the same umbrella, which increases the value of agri-products. And it has become a crucial area to take care of the challenges.

Surveys from Japan and Nepal have found differences in agricultural knowledge, agricultural technology, farm equipment, government aid, consumer behavior, climate and arable land, and agricultural cooperation between the two countries. If suitable policies and technology are transferred to Nepal, postharvest loss of vegetables will be reduced.

Appendix

Appendix -1

Questionnaire for Farmers

Date:

Interview no:

General information

1. Name of farmer:

2. Age:

3. Education:

4. District:

5. VDC/Municipality:

6. Ward no:

Demographic information of family members

7. Total family member..... 8. Male 9. Female.....

AGE	0-15		16-30		31-60		>60		Total
	M	F	M	F	M	F	M	F	

8. Educational information Level

Level	Primary		Secondary		10+2		Bachelor		Masters	
	M	F	M	F	M	F	M	F	M	F

9. Main occupation:

a) Agriculture b) Job c) Business d) others (Specify).....

Information about land and production

10) Total land holding of the respondent

(own/lease)

Cultivated Uncultivated

11) Total cultivated land under vegetable production?

a) Less than 0.1-hectare b) 0.1-2-hectare c) 0.2-0.3-hectare d) more than 0.3 hectare

12) How long have you been involved in vegetable farming?

a) <4 years b) 4-8 years c) 8-12 years d) more than 12 years

13) Why do you choose vegetable farming?

a) Easy cultivation b) more earning c) suitable climate d) others.....

14) Volume of production in a year

15) Season of production in one year?

a) 1 time b) 2-time c) 3-time d) 4-time e) > 4 time

16) Average income from vegetable production annually.

a) Up to 50,000 b) 50,000-1, 00,000 c) 1, 00,000-150,000 d) Above 150,000

17) Have you ever taken any training for vegetable farming?

18) Have you been granted government assistance for vegetable farming?

19) Have you ever faced losses from wildlife?

20) Have you ever faced losses by strikes?

21) What are the postharvest losses in different activities?

Different stage	% Loss	Remarks
Producer		
Harvesting		

Grading Storage Transportation Packaging Supplying		
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Losses during Packaging

22) What method do you apply to clean the vegetables after harvest?

a) Rubbing with cloth b) rubbing with hand c) Washing with clean water d) Nothing

23) Do you grade the harvested vegetable?

a) Yes b) No

If yes, what is the basis of grading a) Size, b) Color, c) shape?

24) What type of packaging material do you use after harvesting?

a) Bamboo basket b) cartoon c) cerate d) others

25) How do you measure the quantity of vegetables after harvesting?

a) By kilogram b) By basket c) By cerate d) others

Loss during storage

26) Do you have any storage facilities? If yes, what type of storage facilities do you have?

a) Cellar storage b) cold storage c) ordinary storage d) others

27) How long do you store vegetables before selling them to suppliers /in the market?

28) How are the losses of vegetables during storage?

a) Decay b) physically /mechanically c) pathologically d) entomologically

Loss during transportation

29) Do you sell vegetables directly in the market or to the suppliers?

30) Which mode of transportation do you use for transporting vegetables to suppliers in the market?

a) Bicycle b) motorcycle c) Self carry d) Truck e) others

31) How far do you have to carry vegetables to sell in the market?

32) DO you experience any loss during Transportation?

a) Yes

b) No

If yes, what is an average loss during transportation?

Appendix -2

Questionnaire for suppliers

Date:

Interview no:

General information

1. Name of farmer:

2. Age:

3. Education:

4. District:

5. VDC/Municipality:

6. Ward no:

Demographic information of family members

7. Total family member..... 8. Male 9. Female.....

AGE	0-15		16-30		31-60		>60		Total
	M	F	M	F	M	F	M	F	

8. Educational information

Level	Primary		Secondary		10+2		Bachelor		Mas ters	
	M	F	M	F	M	F	M	F	M	F

9. Main occupation:

a) Agriculture b) Job c) Business d) others (Specify).....

Volume of supply

10) How many vegetables do you collect from the field at once?

11) How many farmers do you contact before collecting the vegetables?

12) How many times in a year do you collect vegetables from a producer?

Loss during collection

13) From where do you get vegetables? (Name of the place)

14) How do you prefer the packaging of vegetables from the field?

a) Bamboo basket b) Cartoon c) Cerate d) Others

15) What are the postharvest losses in different activities?

Different stage	% loss	Remarks
Grading		
Storage		
Transportation		
Processing		
Packaging		
Insect infestation		
Supplying		

16) Do you grade the vegetable?

a) Yes

b) No

If yes, then what is the basis of grading: a) size, b) color, c) shape?

Loss during transportation

17) How do you bring vegetables from the field?

a) By bus b) Bicycle c) Truck d) Tractor e) Others

19) How much distance do you bring a vegetable from the producer?

20) How much market distance do you sell a vegetable to retailers?

21) How do you measure your loss during transportation?

22) Have you ever faced losses by strikes?

Loss during storage

23) Do you have any storage facilities? If yes, what type of storage facilities do you have?

a) Cellar storage b) Cold storage c) Ordinary room d) Others....

24) What is the type of loss you often see during storage?

a) Decay b) Physically or mechanically c) Pathologically d) entomologically e) Others...

Loss during supply to retailers

25) Do you see any kind of losses during supplying to retailers?

a) Yes b) No

If yes,

a) What kind of loss do you often see during supply to retailers?

b) What is an average loss of vegetables until you supply to retailers?

26) Have you ever been disturbed by strikes?

Appendix-3

Questionnaire for retailers

Date:

Interview no:

General information

1. Name of farmer:

2. Age:

3. Education:

4. District:

5. VDC/Municipality:

6. Ward no:

Demographic information of family members

7. Total family member..... 8. Male 9. Female.....

AGE	0-15		16-30		31-60		>60		Total
	M	F	M	F	M	F	M	F	

8. Educational information Level Primary Secondary 10+2, Bachelor\Masters

Level	Primary		Secondary		10+2		Bachelor		Masters	
	M	F	M	F	M	F	M	F	M	F

9. Main occupation:

a) Agriculture b) Job c) Business d) others (Specify).....

Loss during collection

10) From where do you get a vegetable?

a) Farmer's field b) Wholesalers c) Others....

11) How many vegetables do you collect at a time?

12) Do you see any kind of losses during collection?

a) Yes b) No

If yes, what is the average loss during the collection of vegetables?

13) What are the postharvest losses in different activities?

Different stage	% Loss	Remarks
Grading		
Storage		
Transportation		
Processing		
Packaging		
Insect infestation		
Supplying		

14) Do you grade vegetables?

a) Yes b) No

If yes, then what is the grading basis: a) size, b) color, and c) Shape?

Loss during transportation

15) Which mode of transportation do you use for carrying vegetables?

a) Bus b) Bicycle c) Motorcycle d) Self-carrying e) others....

16) What type of packaging materials do you use during transportation?

a) Polythene bag b) Bamboo basket c) Cartoon d) Cerate e) others.....

18) How far do you bring a vegetable from the wholesaler or producer?

Loss during storage

19) Do you store vegetables?

a) Yes b) No

20) How long do you store vegetables?

21) Do you see any loss while storing the vegetable?

a) Yes b) No

If yes, what is the average loss of vegetables while storing?

Loss during selling process

23) Do you experience any loss while selling vegetable to a consumer?

b) No

25) Do you have to throw away any vegetables due to the inability to sell all of them?

b) No

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