Understanding the Role of Farmers and Government in Fruits and Vegetables Postharvest loss Reduction in Nepal

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ABSTRACT

Agriculture is the mainstay of most of the developing countries like Nepal that has significant contribution to food availability, poverty alleviation and rural employment. A number of research and United Nations reports reveal that growing the quality and quantity of food to feed the growing global population is challenging. Several postharvest scholars expressed that saving food what is already produced is more crucial than focusing on increasing the quantity of food for sustainable development. As mentioned by the Food and Agriculture Organization of the United Nations for growing food, many other limited resources such as land, water, soil, fertilizers, capital and human resources are essential. When the produced food for human consumption is lost during, various stages of the food chain then food loss occurs. Food loss and waste is a global issue that contributes to greenhouse gas emission, and waste of scarce natural resources. Literature reviews reveal that food losses occur in perishable produce more than in other crops, and recorded maximum in the developing countries. In Nepal, fruit and vegetables losses at different stages of the value chain are opined as the challenges for the agricultural sector development. Therefore, this research was conducted in the Dhading district og Nepal with the aim to identify the factors of food loss and to explore the smallholder farmers' strategies and the role of the state in postharvest loss reduction.

The research is based on direct interviews with the farmers and the key informants to identify the actual causes of food loss. Government implemented policies and projects were presented and analyzed. The findings reveal that postharvest loss occurs due to poor postharvest handling and management. On top of this, the fruits and vegetables are lost due to lack of access to the market, unstable market price, failure to compete with foreign subsidized produce, intermediary price control policy, unavailability of well-ventilated transportation, storage facilities, and lack of government support price and market regulation. The farmers' interest lies in the cultivation of traditional crops, method of crop diversification and crop substitution for regulating the overproduction of seasonal vegetables, focus on off-season vegetables and use of organic fertilizer to produce quality product for loss minimization. The farmers' indigenous methods of vegetable fermentation, drying, and pickling are effective method to save what has already been produced. The findings also allow us to conclude that the government policy, strategies, rules, regulations, and supports are equally significant for regulating the acts of all stakeholders in supply chain.

Keywords: *Agriculture, Fruits and Vegetables**,** Food loss, Postharvest loss, Postharvest handling, Smallholder farmers, traditional farming practices, Indigenous knowledge.*

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ACRONYMS AND ABBREVIATIONS

ADS	Agriculture Development Strategy
APP	Agriculture Perspective Plan
CASA	Commercial Agriculture for Smallholders and Agribusiness
DoFE	Department of Foreign Employment
FAO	Food and Agriculture Organization
FLW	Food Loss and Waste
FL	Food Loss
GoN	Government of Nepal
GHG	Greenhouse Gas Emission
ha	hectare
HELP	High Level Panel of Experts
IK	Indigenous Knowledge
IFAD	International Food and Agriculture Development
NARC	Nepal Agriculture Research Council
NGO	Nongovernmental organization
INGO	International Nongovernmental Organization
MoALD	Ministry of Agriculture and Livestock Development
mt	Metric tons
NHPC	Nepal Horticulture Promotion Center
PHL	Postharvest Loss
PHLH	Postharvest Loss Handling
PHLM	Postharvest Loss Management
PMAMP	Prime Minister Agriculture Modernization Project
PPP	Public Private Partnership
SDG	Sustainable Development Goal

TK	Traditional Knowledge
UN	United Nation
UNDP	United Nation Development Fund
VCDP	Value Chain development of Fruits and Vegetables Project

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Chapter 1: Introduction

Agriculture being the mainstay of the Nepalese economy has been playing an important role in food security, poverty alleviation, employment and earning income. Thus, agriculture sector development has been a priority of the state for more than six decades. However, Nepal's agriculture sector still needs to be modernized despite tremendous efforts for commercialization. The Ministry of Agriculture and Livestock Development (MoALD) published a report (MoALD 2016) that states that food loss and waste are critical issues in the food chain of Nepal, and food losses occur at both pre-harvest and post-harvest levels. Yet, addressing food loss is not prioritized (MoALD 2016). Food loss and waste (FLW) are defined as the part of food that can be edible but lost or wasted (HLPE 2014). There is a long process to have food on the plate from farm production to consumption. It requires many resources (land, water, labor, energy) and travels miles until it reaches consumers. Along with food loss and waste, there are financial losses, and other resources also go to waste further, food loss contributes to environmental degradation and greenhouse gas emissions (FAO 2011, v). In developing countries, mostly in the rainy season, the food losses are measured high, that could reach up to 70% in fruits and in green vegetables (Kitinoja and Kedar 2015 p 18). In Nepal, a developing country with a rainy season during the month of June and July, there could be possibility of more fruits and vegetables loss. GC and Ghimire (2019) claim that food loss and waste occur at the post-harvest level and throughout the distribution levels in Nepal, mostly in fruits and vegetables and followed by the dairy products, meats, crops, and cereals. Thus, fruits and vegetables are more delicate and have a high percentage of losses. The geographical structure of Nepal is characterized by hills and mountains, and poor access to infrastructure (road, transportation and electricity), and about 30 to 50 percent of fruit and vegetables produce is lost until it reaches the customers (Bhattarai 2018; DFID 2020). The high percentage of vegetable loss has recorded even though the districts with proper road connectivity still the occurrence of losses in fruit and vegetables is high, and it's a great concern in the Nepalese agriculture sector (Bhattarai 2018). Every year, the farmers throw away their vegetables on the farm or on the road due to low market prices. They also act in this way in order to express disagreement with the government for not regulating the supply chains of the vegetables. This demonstrates that besides proper infrastructure and

access to transportation there might be other reasons behind the factors of postharvest loss that I wish to explore through this study.

Most of the studies on food loss and waste are focused on a storage system or are related to disease-pest, and few of them are dedicated to specific commodities, such as tomatoes, apples, and potatoes (GC and Ghimire 2019). The farmers' knowledge about food loss after the harvest, and their contribution and constraints could be an important factor to save what is already produced. Delgado et al (2017) describes food loss being a critical issue that needs to be addressed, but its actual causes differ according to the types of commodities, and only a few successful interventions on food loss are documented. Ngubo (2021) claims, that the use of the indigenous knowledge approach is a pathway for poverty alleviation, reducing hunger, and for the food security and needs adequate documentation. The Zero hunger challenge, National Action Plan (2016-2025) of Nepal has emphasized establishing a database for the assessment of annual losses and further developing and implementing appropriate loss reduction plans (Ministry of Agriculture development 2016, 58). Nevertheless, the national database on food loss and waste is still difficult to access online or in report form. Nepal seems to prioritize food loss and waste due to the lack of a specific food loss policy, and the Agricultural Development Strategy (ADS 2015-2035) is heavily concentrated on increasing agriculture production and farm productivity (Roka 2017; Kaini 2019). Exploring farmers' knowledge, current practices on post-harvest management and loss reduction may add value to the best practices database. Further, this research could act as a reference document, and could be helpful for the designing and implementation of cost-effective and sustainable techniques for food loss reduction at the grassroots level. This research pursued to identify causes of food loss and document the local knowledge and practices that could be an adoptive approach to postharvest loss.

1.1 Research Questions

1. Why do fruit and vegetables losses occur at the post-harvest level in Nepal?
2. How do smallholder farmers contribute to reducing postharvest losses of fruits and vegetables?
3. To what extend does the government address postharvest loss in developing policy and project for fruit and vegetables loss?

Food loss and waste are, directly, and indirectly related to poverty, climate change, food security, and health (Blakeney 2019). Most of the food losses are due to inefficiencies created in the food system (Ishangulyyev et al. 2019). The farmers have to bear economic loss on the investment due to fruits and vegetables loss. My research aims to uncover the factors that cause fruits and vegetables loss at the post-harvest level and to understand the role of the government in supporting farmers, and further to understand how the farmers' perspectives and indigenous knowledge are seen as important to include in the food loss reduction interventions.

1.2 Objective

The overall objective of this study is to understand the fruits and vegetable loss at the post-harvest level and reduction strategies.

The specific objectives are;

1. To identify the reasons for fruits and vegetable losses in post-harvest levels.
2. To explore the farmers' local knowledge and practices to minimize post-harvest loss in the fruits and vegetables.
3. To document the government policies and programs on fruits and vegetables.

1.3 Thesis Outline

This research contains seven chapters including introduction and summary with conclusion. In the introduction chapter, the needs and motivation behind the selection of the topic are presented, including the problem statement, justification, research questions and Objectives. The second chapter titled Background' focuses on presenting the Nepalese Agriculture development, the geographical and agricultural background of Nepal, farming system, and horticulture development (fruit and vegetables).

Chapter three 'Literature Review' cover the terminology use for food loss, food waste, and postharvest loss, the situation of postharvest loss around the world, the importance of its reduction, the causes of postharvest loss highlighted by the various authors, smallholder farmers and traditional knowledge in postharvest handling.

Chapter four ‘Methodology’ explains the study area and reasons for its selection, the data and information collection methods, the method applied for data analysis, the study area descriptions, the lists of respondents with socio-economic background, the study limitation, and ethical considerations.

The chapter five ‘Findings and Discussion’ structured based on the research questions. The socioeconomic background of the participants is analyzed to know the causes of the postharvest loss, age, gender, family size, education, land holdings, professional, income source. Then, the farming system in Dhading, farmer’s attraction to fruit and vegetables, fruits and vegetables production situation in Nepal and Dhading are studied. To explore the farmers’ knowledge and practices for postharvest handling and management practices, the farmers’ current practices to handle the products after the harvest is studied and their role in reducing postharvest loss through using indigenous knowledge is presented. Finally, the ways in which the government is addressing the postharvest losses of Fruits and Vegetables through the policy, strategy and the projects are studied.

The Chapter 6 incorporates the farmers’ strategies to reduce postharvest loss. The government plans, strategies, and projects that address postharvest loss are presented. Nepal Periodic Plan and agriculture development, and Agriculture plan and strategies of the Nepalese government (Agriculture Perspective Plan (APP) 1995 to 2015, Agriculture Development Strategy (ADS) 2015 to 2035, Nepal Agriculture Policy 2004 (NAP 2004), and Prime Minister Agriculture Modernization Project (PMAMP), and Value Chain Development of fruits and vegetables (VCDP) are presented to describe the role of government in loss minimization.

Finally, Chapter 7 ‘Conclusion’ focuses on summarizing the findings and main arguments of the study.

Chapter 2: Background

2.1 Introduction

The background chapter comprises of geographical overview of Nepal along with farming system, land use pattern in Nepal, historical development and status of fruits and vegetables.

2.2 Geographical and Agricultural Overview of Nepal

Geographically, Nepal is a small and landlocked South Asian country situated in between two big countries India and China. Nepal is well known for having diverse climate and diverse ecological zones. The country is divided into three physiographic zones as Terai or plain (60-300 meter), the hilly (301-5000 meter), and above 5000 meter are the mountains (Bhattarai 2018). Based on area distribution by ecological belt, terai covers 23%, hills 42%, and mountains 35% of the total areas of 147,181 square kilometer, and about 3,092 sq. km (21%) of the total land of Nepal is cultivated (MoALD 2021).

Table: 2.1.a Geographical overview of Nepal with Suitable land for Agriculture Use

Ecological Zone	Total Area (Square Km)	Percentage	Agricultural land suitable Percentage	Total Irrigation Coverage	Percentage
Terai	34,019	23	31	591,139	81
Hill	61,345	42	20	109,384	15
Mountain	51,817	35	6	27,924	4
Total	147,181	100	57	728,447	100

Source: MoALD 2022

According to the Census 2021 the populations has reached 29,192,480 people, among which about 60.4 percent are still engaged in agriculture (CBS 2022). Agriculture as the main occupation of the households is associated with their livelihoods (15th periodic plan). About 53 per cent of the total households possess less than 0.5 ha of land (CBS 2020) hence, the predominance of the larger number of households holding small-scale farmland. Roka (2017)

categorizes Nepalese agriculture as subsistence in nature and almost 40 percent of farmers produce for self-consumption and the surplus 60 per cent sell in the market.

Nepal Horticulture Promotion Center reveals Nepal's agro ecological diversities with variation in topographical, and altitudinal features make it suitable for agricultural production, mainly in the horticulture sector (Gautam et al. 2019). Nepal has tropical, subtropical, and favorable climates, which are appropriate for horticulture production (MoALD 2021). Mainly, the central regions and the lower regions of the Himalayan belt of Nepal are appropriate for horticulture development (Third periodic Plan 1965-70). Since the second periodic development plan, horticulture development has been given priority, and has established horticulture development centers were established in different districts. Nepal has initiated vegetable growing centers. In addition to the production of fruits and vegetables, attention provided for the preservation. A preservation center was established at the Kirtipur Horticulture Centre during the Second Plan (1962-65). With the increasing trends of vegetable consumption and high rate of return on investment, vegetables crops in Nepal are considered important. According to Commercial Agriculture for Smallholders and Agribusiness (CASA), about 3.2 million families are engaged in vegetables production (CASA 2020). In the fiscal year 2020/21 agriculture contributes 15.44 % to GDP in which fresh vegetables and fruits contribute 4.79% and 2.17% respectively (MoALD 2021).Though total vegetables production has reached up to 3.96 metric tons, tons of fruits and vegetables are imported from India, China and other countries. While, approximately 20 to 50 % is lost after harvest and all the produce could not reach the market for consumption (Bhattarai 2018).

Table: 2.1.b Land distribution in Nepal

Types of Farmers	Land holding size
Landless	0-0.1 ha
Marginal	0.1-0.3 ha
Small farmers / Subsistence Farmer	0.3-0.5 ha
Medium farmers	0.5-3.0 ha
Large farmers	3.0-10 ha
Very big farmers	>10 ha

Source: Roka (2017)

Based on landholding size, Agriculture Development Strategy (ADS 2015-2035) categorizes the farmers as small commercial farmers with holding land size (1 to 5 hectare) and subsistence farmers (0.5 to 1 hectare). Roka (2017) states that Nepalese agriculture is subsistence in nature however, due to road and market access, commercialization in the farming sector is getting popular in Nepal (Timsina 2022). The farmers produce for self-consumption and sell some portions in the market were selected as respondents because their postharvest losses are assumed high as they neither can consume all the harvested produce nor have suitable infrastructure to store and access to market to sell the produce.

2.2 Farming System and Land Use Pattern in Nepal

Nepal is an agriculture based economy with more than half of the total population's livelihood depending on the agriculture sector, which provides two third of employment. The cultivation system is rain fed due to lack of proper irrigation system. About 56% of Nepal's total arable land has irrigation facilities, and only one-third of farms have all year round irrigation (CBS 2021). The rest have to depend on rain-fed agriculture. In the fiscal year 2020/21, based on land use distribution by use category, about 3,091 thousand hectares (21%) of agricultural land was cultivated and 7 % land was uncultivated (MoALD 2022). The majorities of the farmers hold less than 0.5 ha of land, conduct traditional, and subsistence farming practices and categorized as smallholder farmers (Roka 2017). A large percent of the total population still considered agriculture as their income source for livelihood. The integrated multi-cropping farming system is in practice in Nepalese agriculture with cultivation of vegetables, fruits, spices along with raising livestock and poultry are the features of Nepalese agriculture. The smallholder agriculture system provides a huge employment opportunity to the majority of the low-income people (Roka 2017). The population census 2011 revealed 76.46 percent of the total population of Dhading were engaged in agriculture (CBS 2011). Just like other hilly regions of Nepal, Dhading is well known for cereals, cash crops, pulses, potatoes and horticulture production of vegetables and fruits (MoALD 2022). The traditional farming system is still in practice in the district with use of traditional knowledge, traditional agricultural tools, organic fertilizers, natural resources and labor-intensive farming. However, some smallholder farmers seem to adopt 'plastic tunnel farming' for producing off-season vegetables for commercial purposes. This is a great transformation observed in the field. Almost all interviewed farmers still preferred mixed cropping agriculture with a view to be

self-sufficient and want to have both work and income all over the year. Due to the subsistence nature of farming, the farmers used to cultivate as many crops as possible in the same land depending upon the crops types, climate and soil suitability. Thapa and Dhimal (2017) claim growing different kinds of crops is sustainable maximum use of resources, and multiple cropping is a better alternatives as a mitigating strategy to cope with the adverse effects of climate change (Paudel 2016). Multiple cropping is popular among the marginalized smallholder farmers of the hills and mountains adopted for self-sufficient in food and able to sell surplus for income (Paudel 2016).

In Nepal, the cropping system varies depending upon the land types (upland or lowland, irrigated or non-irrigated), soil types and climatic condition. The moderate climate found in the hilly areas of Nepal provides opportunities for the farmers to do year round agricultural activities and produce many varieties of fruit and vegetable. In the hilly areas, the farmers practice three types of cropping systems; paddy-based, maize-based, and vegetable-based (USAID 2011). In irrigated lowland of hill, the farmers cultivate paddy followed by wheat/potato/legumes-maize/vegetable/rice. While in upland maize and millet/upland paddy/legumes-blackgram/vegetables/legumes/potato were cultivated (Dahal 2010). Until 1980, there were very limited crops such as rice, wheat, maize, millet, barley, buckwheat, potato, garlic, ginger, and board mustard leaves (Ghimire et al 2022). At present, vegetable-based cropping system is getting priority because of high income possibilities (USAID 2011). The cropping diversification and pattern changes accordingly with change in climate, out migration and off-farm employment, market value, infrastructure development and connectivity, extension service and training and changing pattern of food habit (Ghimire et al 2022).

2.3 Historical Development of Fruits and Vegetables in Nepal

Nepal is enriched with distinctive agro-ecological climatic condition with different geography and altitudes, which provide enormous opportunities for fruits and vegetables development (Thapa and Dhimal 2017). The fruits and vegetables are an integral part of farming in Nepal. The historical record of horticulture development was initiated from the Pre-Rana Prime Regime but scientific cultivation was realized in 1940s from the Indian fruit experts (Kaini and Shrestha 2016). Thapa and Dhimal (2017) mentioned that before 1950s only indigenous fruits and vegetables were grown but Rana Prime Ministers expanded through the collection of

varieties of fancy and exotic fruits and vegetables and grew them in the private garden named "Putali Bagaincha" in Kathmandu. During mid-19th century, Jung Bahadur Rana a Rana a Prime Minister and his dignitaries received European fruits and vegetables seeds as gifts from Great Britain that were slowly spread to many parts of the country (Pandey and Shakya 2016). Later on in 1948 and in 1959 two horticulture units were established, several horticulture farms were established in the 1960s in different ecological zones for promotion of fruits in the country (Kaini and Shrestha 2016). Several countries and international organizations including Indian Cooperation Mission, German organization (GTZ), Japan International Cooperation Agency (JICA), Canadian International Development Agency (CIDA) and many others supported the implementation of numerous projects for horticulture development in Nepal. This shows horticulture development was given priority by the government and from the international organization and the gifts received from the several countries are the reasons for the expansion of varieties of spices of fruits and vegetables. The official vegetable development started in 1937 through establishment of the Agriculture Council which was renamed as the Department of Agriculture in 1952, and later on Department of Horticulture functioned from 1967 to 1972 (Pandey and Shakya 2016). Nepal Horticulture Society (NHS 2016) mention at present, government has separate fruits and vegetables development department, and are functioning to expand its cultivation based on agro-ecological zones. The demand and expansion of fruits and vegetables crops in all over the country, and due to best-suited ecological and climatic situation the government is plan for commercialization of horticulture.

2.4 Fruits and vegetables production Situation in Nepal

Statistical information for the fiscal year 2020/21 (MoALD 2022) shows that 2,84,121 ha land was used for vegetable cultivation and about 3,993,000 tons production is recorded.

Table: 2.2 Share of Agriculture in National GDP in last 5 fiscal year

S.N	Sectors	Overall Contribution in GDP (%) at current Price				
		Fiscal Year				
		2017/18	2018/19	2019/20	2020/21	2021/22
1	Agriculture	16.60	16.16	16.51	16.29	15.60
1.1	Cereals and other Crops	9.72	9.65	9.61	9.18	8.34
1.2	Vegetables, Horticultural, specialties and nursery products	5.58	5.20	5.50	5.84	5.99
1.3	Fruit, nuts beverage and spice crops	1.30	1.31	1.40	1.27	1.27

Source: MoALD 2022

The favorable climatic conditions for growing all year-round vegetables benefit the farmers. The government has announced that it will double the productivity of vegetable cultivation in five years. But according to the Central Statistics Office, the average annual growth rate of the agricultural sector has been only about 3% over the past decade. Experts say the main reason is the lack of adequate fertilizer, slow pace of adoption of mechanization, poor farm management, lack of irrigation facilities, climate change and unrecorded postharvest losses. The rain fed agriculture system is another challenge for the farmers (Dahal 2010). The farmers have to be more conscious about the climate and characteristics of the crops.The farmers follow a cropping calendar for the rotation system. The cultivation and harvesting of the crops need to be on good time. The farmers have to clear the produces from farm to cultivate next batch of crops. Even though the harvested produce, has less market price the farmers either sell it at low price or have to discard it.

2.7 Summary

This section deems to present an overview of agriculture in Nepal including farming practices, cropping patterns, the fruits and vegetable growing trends. The geographical structure, the categorization of the farm land and the farmers are presented to the reader in order to provide background information about Nepal and its agriculture sector.

Chapter 3: Literature Review

3.1. Introduction

Literature review includes the concepts of food loss and waste, occurrence, causes of postharvest losses and necessities for loss reduction. Further, the concepts of smallholder farmers, their farming practices, traditional / indigenous knowledge (IK), and postharvest handlings practices are introduced. It also discusses the reasons for food loss presented by various scholars, the smallholder farming impacts of using indigenous postharvest practices and technologies.

3.2 Terminology of Food Loss, Food Waste, Postharvest Loss

Food loss and waste (FLW) are defined, as the part of food that can be edible but is lost or wasted (HELP 2014), and the food loss can occur either quality or quantity, or both (Blakency 2019). HLPE (2014) has mentioned when there is food loss and waste issue while millions of people have no access to food, and are hungry, the situation indicates the global food system is not functioning effectively, and points to its injustice and incompetence. According to the HLPE (2014) report, the food loss and waste (FLW) is stated as a decrease in food whatever the cause, in all stages of the food system from production to consumption in quantity or quality of the food, which was for human consumption.

Food loss and waste is an important issue, and it needs elements of strategy, and should not be seen in isolation and country-level food loss and waste strategy is important to develop (World Bank 2020).

Food loss refers to decrease of food before it reaches the consumer while food waste is thrown away or left to spoil even though it is appropriate for human consumption so it is intentional and occurs at the consumer level due to negligence. It has been stated that food loss is unintentional and generally occurs in the whole supply chain that starts from production to harvest, the post-harvest handling, storage and processing, and transportation HLPE (2014). When the harvested food decreases in quality and quantity along the supply chain before it reaches the market it is identified as postharvest loss (FAO 2018). Postharvest loss is counted

as qualitative and quantitative loss of the produce that occurs in the value chain at different stages from harvest to the final consumption (Kitinoja and Kader 2015).

Food loss occurrence is high in developing countries where agriculture is the mainstay of the economy, but the country is food insecure with a large number of smallholder farmers prevalence of small-scale subsistence farming (FAO 2021). On one hand, the agricultural produce for human consumption is lost and wasted while a large number of the population of the nation and the people around the globe are dying because of hunger and malnutrition. Almost 14 percent of harvested food is lost before it reaches retailers for sale and the consumers, and the developing countries are the most affected (FAO 2019). Mayienga and Cachia (2021) conducted a study in 48 countries and found that the southern Asia has a high percentage of loss occurrence on fresh vegetables (21%) which is followed by sugar crops (19%), roots and tubers (18%) and fruits (17%). According to Faqeerzada et al. (2018) due to lack of postharvest handling technologies, the South Asian farmers have to bear 20% to 44% losses in fruits and vegetables. The literature on postharvest reveals various percentages and levels of losses in different vegetables, for example the leafy vegetables and tomato are highly delicate with heavy amounts of moisture contained so the loss reaches up to 50 percent in adverse situations (Bhattarai 2018). The postharvest loss percentage varies in between the commodity types, places, regions and the country and its economic and environmental impacts are often hard to calculate (Odyemi et al.2021). Due to high initial cost of postharvest technologies, the farmers could not afford and use them (Kitinoja 2013; Faqeerzada et al.2018).

3.3 Postharvest loss

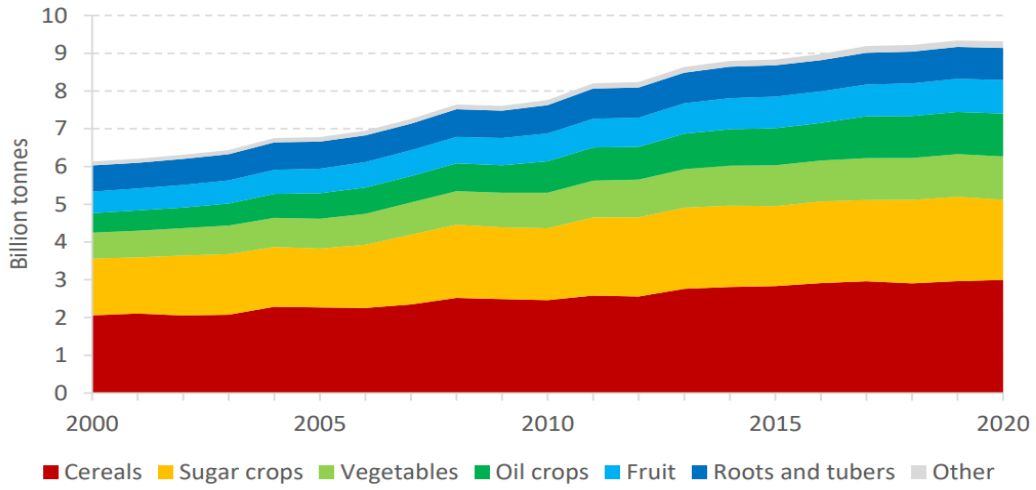
The food and agriculture organization of the United Nations (FAO) defines postharvest loss as “the loss of food that is produced for humans but not able to be consumed by humans due to loss in quality or quality from the various reasons”. According to the (FAO 2011) statement, even though food is utilized through feeding domestic animals still it is recorded in food loss. The food that never reaches the consumers get lost in the supply chain due to various reasons that could be harvesting, grading, sorting, packaging, and transporting. The definitions of postharvest loss in academic literature can be summarized as the qualitative and quantitative losses that could be in weight, nutritional value and economic losses occur of the agricultural produce that occur during the value chain that is in between harvest to the storage and

consumption (Kader 2005; Kitinoja 2015; Luciana et al.2017; and Mayienga and Cachia 2021). Thus, postharvest loss is food loss that could be in quality and quantity, or both after right after the harvest when produce enter the supply chain until it reaches the consumer's plate for consumption.

3.4 Situation of Postharvest Loss

The postharvest loss is more concerned with the problems of unsellable and unconsumed produced food due to technical adequacy of a postharvest handling. Along with the food, other resources such as land, water, chemical, labor, capital used for the production are also being lost and contribute to Greenhouse gas emission (HLPE 2014). Food loss was more immense in developing countries than in developed countries because of various socioeconomic reasons (Kader 2005). Food and agriculture statistics 2021 shows the global production of main crops such as rice, maize, wheat, sugarcane have increased by 52 percent that amounts to 9.2 billion tons in 20 years, similarly, fruits and vegetables production increased by 55 Percent (887 million tons) and 65 percent (1128 million tons) respectively (FAO 2020). The following figure shows the upward trends of the global production of commodities from 2000 to 2020 years.

Figure: 1 Global Crops production



Source: FAO 2021 Agricultural Production Statistics 2000-2020

The FAO report on food loss and waste shows that 14 percent of world's food produce that amounts to $400 billion are lost annually in between the harvest and retail market (FAO 2019). The loss percent includes all agricultural produce (cereals, vegetables, fruits, roots and tubers,

sugarcane). While the loss percentage of fruits and vegetables is high and estimated to be about 30 to 50 percent. Kitinoja and Kedar (2015) claim the loss percentage of fruits and vegetables has not changed a lot from the first published report by the National Academy of Science that presents 30 to 40 percent loss during the 1970s and at present. Similarly, Khatiwada and KC (2021) also figure out that the research conducted in between 1991 to 2019 reveals that the postharvest losses situation of the fresh produce in Nepal is still in the same percentage as 3 decades (Table 2). The global production is increasing while loss is still in the same range; it shows the loss amount is more in average at present and challenging for sustainable production and consumption. Thus, the hindering factors or causes of postharvest need to be identified prior to the loss minimization interventions on a local to global scale. The scholars claim socioeconomic, environmental and behavior change of the consumers are the factors that are responsible for the large percentage of postharvest losses (Kader 2005; Kitinoja 2013, KC et al. 2016)

Table: 2 Estimation of Postharvest losses of fruit and Vegetables in Nepal

Commodities	Postharvest losses (%)	References
Vegetables Fruits Potatoes	25 20 32	MHD, 1991
Vegetables Fruits Potatoes	20-35 15-30 15-20	Kaini, 2000
Fresh Produces	20-30	Karki, 2002
Perishables	20-30	Adhikari, 2006
Fresh produces	15-35	Gautam et al.2019

Source: Khatiwada and KC (2021)

There are internal and external drivers of food loss and it varies by the region, country, and the nature of the commodity (FAO 2020). Post-harvest losses in fruits and vegetables result from their inherent perishability, which is aggravated by environmental conditions such as high temperature and relative humidity that enhance deteriorative changes in the produce.

3.5 Causes of Postharvest losses on fruits and vegetables

Fruits and vegetables are considered as living organisms that remain alive even after being harvested Adhikari and GC (2021). The respiration process persists, and with proper handling practices, they can stay. However, various factors can contribute to damage and loss of these products (Bhat and Khan (2017). The agricultural scientists have identified different causes of food loss, that are biological, chemical, physical, physiological and mechanical that damage fruits and vegetables leading to an unpleasant look, flavor and unsuitable for consumption and are considered as food loss. The postharvest losses can occur during any of the various steps of the agricultural postharvest system that could be physical losses, qualitative losses and a decrease in economic value of the produce (Kitinoja and Kader 2015). The lower the market channel, the lower the chances of postharvest loss from the physical damage (Subedi and Gautam 2019) because it decreases the chances of human involvement in transportation. Bhat and Khan (2017) state both internal and external factors are responsible for the postharvest losses of fruits and vegetables. The external factors that influence fruits and vegetables shelf life happen in different stage of postharvest handling supply chain (harvesting, handling, grading, sorting, packaging and transporting) whereas, internal factors are related to produce's temperature, respiration rate, oxygen, carbon dioxide and ethylene use for ripening (Adhikari and GC 2021). Pre-harvest factors such as insect infestation and rainfall also have a major impact on postharvest losses (Kitinoja and Kader 2015). The climatic variation causes loss as the vegetables are transported in non-refrigerated vehicles during the summer from hilly regions to terai a hotter part of the country (Khatiwada and KC (2021). Loss percentage depends on the perishability nature of the produce; high perishable, moderate perishable and low perishable (Kitinoja and Kader 2015). Highly perishable means more chances of loss (Bhat and Khan 2017). For example, leafy green vegetables and tomato loss contain high moisture and perishability that leads to high postharvest losses (Tiwari et al.2020). Based on several lectures by Adhikari and GC (2021); Subedi and Gautam (2019); Bhat and Khan (2017); and Kitinoja and Kader (2015), the food losses are categorized as;

Table: 3.5 Types of food Loss and Causes

Types of Loss	Causes
Biological	damage by pest and disease
Physiological	quality loss damage from sprouting, rooting, senescence, and changes which is caused by transpiration and respiration, chilling ambient condition
Mechanical Injuries	damage due to cuts, bruises, grazes, drops, scrapings, shatters during harvesting etc
Physical	damage due to Water loss, heating, cooling and freezing
Chemical	contamination with pesticides and chemical products, toxics and unpleasant flavor produced by pathogens

Source:

3.6 Factors of Postharvest loss

There are socioeconomic, environmental, human factors and nature of the produce all have an important role in postharvest loss.

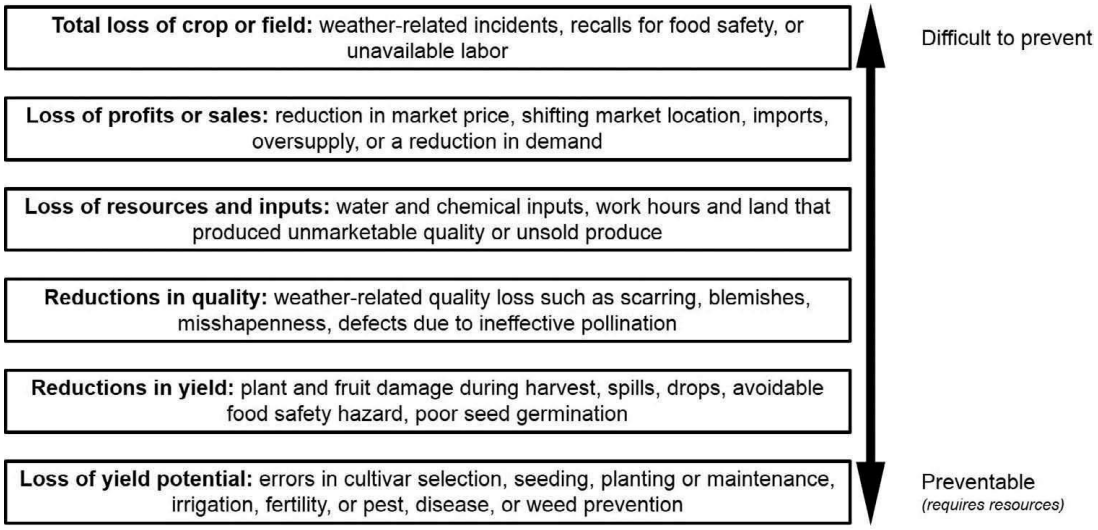
Table 3.6 Factors of Postharvest Loss

Factors	Reasons	Solutions	Authors
Human (behavioral)	Carelessness in postharvest handling while loading and unloading that cause internal brusing, physiological damage splitting and skin break lack of knowledge and skills	Training and awareness	WWF 2021 Faqeezada et al.2018
Socioeconomic	Government regulations and legislations Lack of tools and equipment Lack of information Communication Small scale production nature	Socioeconomic factors have to address for PHL reduction	Kader 2005, KC et al. 2016 Sugri et al 2021
Infrastructures	Road, Inadequate and proper Transportation, Power supply, Storage (farmers are forced to sell at low process due to lack of storage)	Refrigerated vehicle lower cost storage	Adewoyin et al. 2022 Khatiwada and KC 2022 Faqeezada et al.2018
Methods	Traditional Method (Local basket used for packing and transportation that causes loss in transit)	Modern plastic crates suitable that reduce mechanical damage, cuts, bruises	Adewoyin et al. 2022 Faqeezada et al.2018 Luciana 2017

	Use of traditional harvesting tools Maturity at the harvest		
Postharvest handling techniques	Lack of harvesting handling techniques Training and Experiences	Technology, improved seeds and proper soil management techniques reduce substantially that reduce loss at producer level	Kitinoja and Kedar 2015 KC et al.2016 Luciana 2017 Adhikari and GC 2021 Shiwakoti and KC 2022
Environmental (External factor)	Climate change Unexpected weather Influence of biological and environmental factors(Direct drivers) Heavy rainfall, storm, hailstorm Temperature	Grow climate resilience products Weather forecast app Use of new procedures and technologies	Costa 2014 Luciana 2017 WWF 2021
Market structure Governance, and Investment	Poor marketing strategies Market Infrastructure Market distance		Kitinoja and Kader 2015 Rai et al 2019 WWF 2021 Adewoyin et al. 2022
Market Price	Recurrent market Price fluctuation	Government strategy in fixing minimum support price	Rai et al. 2019 Bhattarai and GC et al.2020

In developing countries, postharvest loss is challenging in agricultural production and in the value chain (Balana et al. 2021). The numerous underlying postharvest loss causes identified by the scholars revolve around the human factors that include knowledge and skills, methods and practices, carelessness, infrastructures, market linkage, marketing, information and communication for handling postharvest produce. According to Johnson (2020) farmers focus on preventing as much losses as possible during the production and sale; however, every loss occurring is difficult to prevent, as presented in figure 2. The Figure 2 shows the farmers can make efforts to minimize quality and quantity of the produce related losses but in terms of market and weather-related factors of losses are difficult to prevent. In case of market price and imports the government policy and strategies are significant (Bhattarai and GC 2020). In order to reduce preventable losses, research and investments are significant and also to minimize pressure on resources and its impacts (FAO, IFAD and WFP, 2021).

Figure: 2 Fruits and Vegetables losses occurrence ranked based on preventable and difficult to prevent



Source: Johnson (2020)

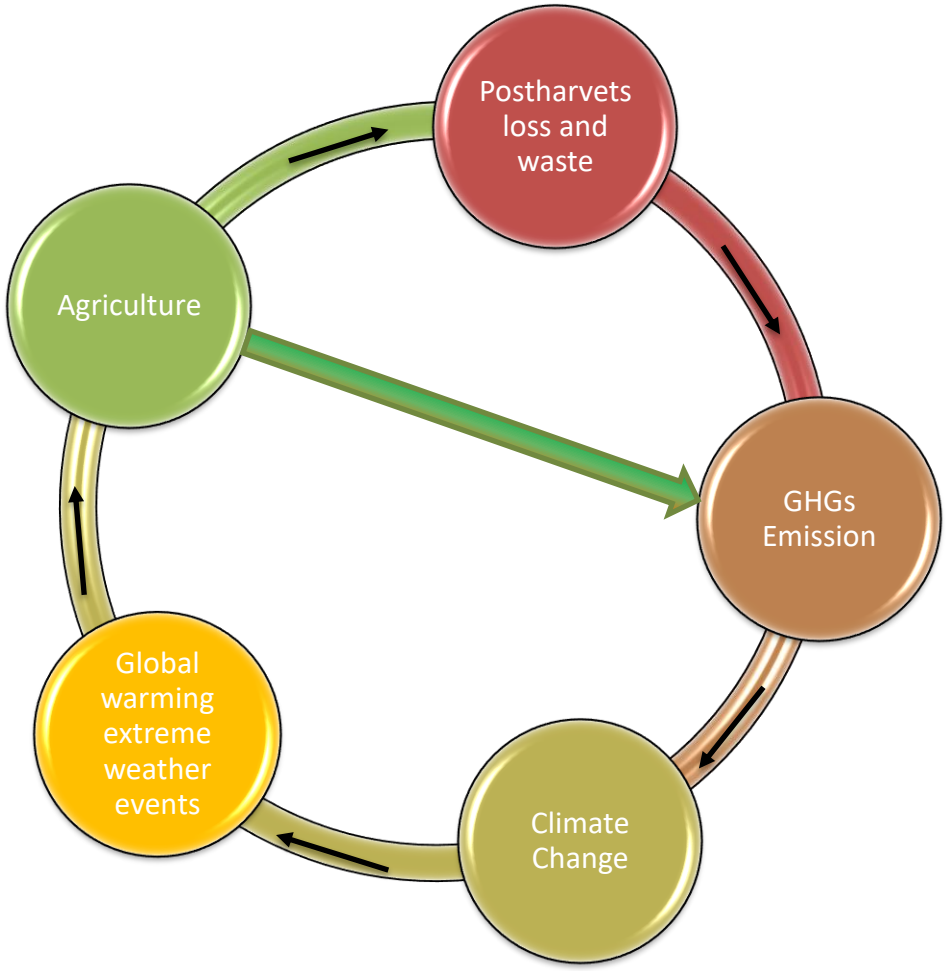
3.7 Importance of postharvest losses Reduction

Food loss reduction is important for promoting sustainable food systems, for decreasing pressure on land, food availability, poverty reduction (Kader 2005), for addressing food insecurity (KC et al. 2016), for hunger elimination, and farmers' livelihoods improvement (Kumar and Khalita 2017). There are numerous things associated with the postharvest losses.

When the food produced for human consumption is lost in the field or in the value chain due to various causes then all the input resources (labor, water, power supply, seeds, fertilizers, packaging materials, capital) required for the production and marketing is lost (Johnson 2020;WWF 2021). The farmers' expected profit from the sales is lost along with the produce lost, that is economic loss and to handle wasted food needs additional cost to the wholesaler and to the municipality. Postharvest loss is an additional cost to the consumer and decreases in profit or sometimes loss to the farmers and producer (Luciana 2017). Postharvest loss reduces income of the smallholders whereas the consumers have to pay more. Food loss and waste are the contributors of 8 percent greenhouse gas emission and contributors of climate change (FAO 2017). The postharvest loss is affecting three pillars of a sustainable food system; people, planet, and profit. Kumar and Khalita (2017) claim that the cost of postharvest losses reduction is more profitable than investment for additional production to meet global demand. Food loss is not only the problem of farmers or producers and developing countries, it's a global issue and needs cooperation from all the stakeholders.

The farming system practices and cropping pattern are the significant factors for quality and quantity of food production. Agriculture contributes to the climate change through producing carbon dioxide ($C0_2$), methane (CH_4) and nitrous oxide (N_20), and then climate change affects agriculture through global warming, and other ways through agricultural food loss and waste contribute GHSs due to this, global warming, extreme weather events, drought, less rainfall and unexpected rain occur (indicator of climate change) affect agriculture (FAO 2022). Singh and Singh (2017, 297) claim "Agriculture and climate change are correlated". Thus, breaking the cycle presented in figure 3 is important for which good agricultural practices adaptation could be significant to address the impacts of climate change.

Figure: 3 Food loss contribution in Greenhouse gas (GHG) Emission and Climate Change



Source: Derived from FAO 2022 above statement

Sikha et al. (2020) claim "the smallholder farmers are vulnerable and highly affected from the impact of climate change due to nature based traditional farming practices and lack of adaptation capacity". Most of the interviewee farmers explained "they have been experiencing changes in weather (increased temperature) and rainfall since a couple of years that have affected crop production". The agro ecological features of traditional agricultural practices have climate adaptation and mitigation potentiality (Singh and Singh 2017). Lakharan et al. (2017) also claim crop diversification as an effective adaptation strategy that is beneficial to farmers in numerous ways such as in reducing whole crops failure, balancing ecosystem and natural biodiversity, reducing insect pests, increasing soil fertility, increasing food supply and increasing source of income. Around the globe, to cope up with the changing climate impacts,

the old traditional agriculture farming method is slowly getting attention for sustainable food production (Singh and Singh 2017). Feeding billions of people entails an increase in food production but having to reduce GHGs from agriculture is a great challenge to the world. The smallholder farmers' 'traditional farming practices are nature friendly and climate resilience' (cited in Singh and Singh 2017), and contribute significantly to food production and food loss reduction. Miniruzzaman (2019) study finds out the temperature effect on crop diversity, with an increase in annual temperature the farmers cultivate diverse crops in high temperature areas while less in low temperature and due to an annual temperature increased by 1 degree centigrade by 2030 there will be 26.40% increases in crop diversity compared to 2010. Thus, it can be assumed that in the coming years global temperature is rising, cropping pattern with more crop diversity will be selected in coming years, and organic farming practices can be promoted and adopted for sustainable agriculture.

There is a conception that food loss is a problem of developing countries whereas, food waste is a problem in developed countries (FAO 2017). Mayienga and Cachia (2021) mention that the literature on food loss highly presents food loss problems that are more acute in developing countries particularly, in South and Sub-Saharan Africa and income poor countries are responsible for low food loss. KC et al (2016) study mentions that infrastructure, road, communications networks were the determinants of loss, and the level of food losses is more in upper middle-income countries as compared to the lower middle countries. The study of Kitinoja and Kader (2015) where the authors have included literature from the 1970s to 2000s found the food loss level varies according to region, country, commodities and the seasons however, it is in practice to range postharvest loss as 30 to 50%. The problem of the postharvest loss is associated with developing countries because the majority of the farmers are smallholders doing subsistence farming systems, traditional postharvest handling practices and unstructured markets (Faqeerzada et al. 2018).

3.8 Smallholders Farmers and Postharvest Loss

In developing countries, such as Nepal livelihood of more than 70 percent of the total population's still depends on agriculture. Most of the farmers are smallholder or small-scale farmers, do subsistence farming, and own less than five acres land. In South Asia, the majority of the farmers belong to smallholders, and the agricultural system is still traditional (Faqeezada

et al.2018). The smallholder farmers are also known as pastoralists as they are highly dependent on their own grown produce and livestock raising. However, different countries have their own landholdings to categorize smallholders, for example, Agriculture Development Strategy (ADS 2015-2035) of Nepal puts farmers category of smallholders, when the farmers hold less than 1.23 acres (0.5 hectare) of land. The large percentage of the smallholder farmers inhabit in developing countries and are the producer of about 80 percent food for Asia and Sub-Saharan Africa, and almost 2 billion people's livelihood depend on these farms (IFAD 2019). As defined by the Food and Agriculture organization (FAO 2012) "smallholders" are the small-scale farmers; they can be pastoralists, forest keepers, and farmers who manage less than 1 to 10 hectares of land. In Nepal majority of the farmers inhabit in rural areas are smallholders and they possess less than 0.5 hectares land for their livelihood (Roka 2017). Less land ownership, subsistence and traditional methods of farming along with livestock raising are the features of smallholders. Family members are involved in small-scale farms for their own consumption and sell surplus food. The smallholder farmers around the globe produce one third of the food (Lowder et al.2021). Family labor and rain-fed agriculture is a common and undertaking traditional method of farming practices in developing countries (Roka 2017). The smallholder farmers cultivate multiple crops on the same land and are more concerned with feeding the family for the whole year from their own productions. Along with subsistence farming, the mixed cropping farming system is another characteristic of smallholder farms. The smallholder farmers having less land ownership focus on utilizing land as much as possible and grow multiple crops together that do not affect one another in growing and fruiting For example, beans, pumpkin and soya can grow together in a maize field. Mostly, the farmers use traditional methods in fruits and vegetables production and continue to harvest, grading, packaging, and transporting until they sell to the intermediaries, businesspeople or in the (local) market (Devkota et al. 2014). The developing countries' resource poor smallholder farmers used traditional poor postharvest handling in the value chain is causing high-level food loss (Devkota et al. 2014; IFPRI 2017; Faqeerzada et al.2018; Adewoyin et al. 2022). Bhat and Khan (2017) claim, that traditional method of storage and preservations are beneficial to economically developing countries because in terms of cost and effectiveness the method is more suitable than high-cost modern methods. The traditional knowledge (TK) used in agriculture is intrinsic and inherited from generation to generation when people began to do agriculture for livelihood (Azad et al.2014). Therefore, understanding the science behind traditional methods along with improvising with needs and conditions is necessary (Bhat and Khan 2017).

3.9 Indigenous Knowledge and Postharvest Handling

When humans interact with nature for livelihood then different ideas are generated and are known as indigenous knowledge (Rawat et al 2000). Indigenous knowledge (IK) is innovative and passed from generation to generation, local use of bio resources, skills, and practices are mostly used in food processing, preservation, packaging, storage, and in transporting the harvested produce. Countries have their own culture and indigenous knowledge but it is being neglected to adopt modernization (Azad et al, 2014). People are gradually getting away from the traditions due influence from western culture, the cultural practices which are unique are rare and gradually disappearing, therefore from the cultural aspect documentation of traditional knowledge and practices is important (Asogwa 2017). IK is the social capital of the local people (Nugbo 2021) and, to understand IK methods, process, and scientific reasons behind the practices is equally important to preserve food (Bhat and Khan 2017). IK is for future food saving, food availability and food security (Kader 2015). Local people are rich in IK and indigenous harvesting knowledge is native method, and has been culturally practiced for generations (Adewoni et al, 2022). IK used in storage of vegetables practiced for generations for consumption in off-season or use in difficult times. For example; sun drying, fermentation, frying, pickling, smoking, salting, sugaring, jellying, cooling are some indigenous methods practiced in different parts of the world, these cultural practices help in loss reduction through utilization of harvested produce (Asogwa 2017; Bhat and Khan 2017; Adewoni et al, 2022).

Chapter 4: Methodology

4.1 Introduction

Research methodology implies the way of performing various methods required to get the purpose of the study. As Thomas (2013) explains, a methodology is also a research design that describes the reasons why the researcher has chosen to do the research in a certain way. This chapter contains the methods, research design, and research analyses along with the description of the study area, the data collection procedures, limitations of the study, and ethical consideration. Further, I write up on challenges that come up during field visits, selecting study areas, and interviewers.

Most of the literature I reviewed while understanding the concept and driving factors for postharvest losses and its complications in reducing, have followed quantitative methodology with statistical analysis where farmers perspectives on postharvest loss is hardly presented. Therefore, I have chosen to use the qualitative approach to understand the roles of the smallholder farmers in managing the harvested fruits and vegetables that are ready for human consumption. Therefore, I chose to conduct interviews, using them as a primary source of data collection with the smallholder farmers who hold the features of subsistence farmers and sell portions for income gain in the mid-hills of Dhading and interview with key informants to know about their perspectives on postharvest losses, government role in reduction of PHL and about the ongoing program and activities.

4.2 Description of Study Area, Dhading district

The climatic variations, geography, and soil quality make Nepal suitable for growing all types of fruits and vegetables (MoALD 2021). For the selection of location for primary data collection, first some overview about the pocket area of the fruits and vegetables cultivation in Nepal was gathered from official and nonofficial reports and documents of the government and nongovernment organizations. Dhading district of Bagmati Province 3 was selected as the study area because the fruits and vegetables production and consumption are high in the central region (MoALD 2021) in comparison to other provinces. The increased demand for fruits and vegetables in Kathmandu valley due to the demand of the highly dense population, existence

of star hotels, guesthouses, lodges, resorts, restaurants, and business hubs has encouraged farmers in vegetable cultivation. The district is 53 km far away from the capital Kathmandu and it takes 3 hours to reach it via Prithvi highway that comes across Dhading. Dhading is one of the biggest districts, its area is 1926 square kilometers with 'Dhading Besi' as a district headquarter has great potential for fruits and vegetables cultivation lies in the central development region of Nepal. The selection of Dhading as the study area was motivated by the fact that the district is inhabited by approximately 3 million populations with diverse backgrounds, and represents a multi-ethnic, multilingual, and multi-culture community. Based on the information on division of population by ethnic groups and caste it can be said that Brahmin and Chettri live in the southern hills, Newar and Magar reside in the east whereas Gurung and Tamang live in the north. The indigenous people Chepang and Praja are marginalized groups, and live in this district with distinct tradition and culture. The district is famous for its enriched agroecological landscape and six climatic zones (upper tropical, subtropical, temperate, subalpine, alpine and Nival) provide enormous scope for fruits and vegetables production. Dhading stretches from the mountain 'Ganesh Himal' to the hills and Terai (plain) area where the northern part of the district is covered with a range of mountains and full of medicinal plants. The mountain people raise livestock; sheep, yak, goats for milk and wool, and seasonal collection of medicinal herbs and sales for generating income is in practice. Still agriculture is the main occupation for their livelihood. The mid hill of Dhading is famous for vegetable production, ginger (cash crop), and different types of fruits (orange, banana, litchi, and mango). The government-implemented project 'Prime Minister Agriculture Modernization Project' (PM-AMP) has considered Dhading as a zone for vegetables, potato, and maize. Dhading district profile mentioned that potatoes are grown in almost 10 rural municipalities for both household consumption and commercial commodity. According to the Kalimati fruits and vegetables development board (KFVDB), almost 20 to 22 percent of the vegetable demand of Kathmandu is fulfilled from Dhading (KFVDB 2022). The district is bordered with main major cities Kathmandu, Chitwan, and Makawanpur increasing the scope for agricultural produce marketing. Furthermore, the Prithivi highway, which is one of the busiest highways, that come across the dhading to connect the central region with eastern, western and far western regions of Nepal open up a market of vegetables for local people. All these distinct features distinguish Dhading from the other districts of Nepal, and it is chosen with an interest to know local people's fruits and vegetable harvest management practices.

Dhading being a potential district for production of tons of fruit and vegetables is supplying the largest portion of its produce to the Kalimati fruits and vegetables development market in Kathmandu. Similarly, Balkhu fruits and vegetables market is another emerging wholesale fruits and vegetables market in Kathmandu. From these wholesale markets, the fruits and vegetables are distributed in various parts of the city. The hotels, restaurants and retail shops are the main customers of these Kalimati and Balkhu markets.

Map 4.3 Study Area

Source: Survey Department Government of Nepal

4.2.1 Fruits and Vegetables Production in Dhading Methodology

National statistical data recorded 58 different types of commercial vegetables production in Nepal. Among them, 38 varieties of vegetables and others different types are produced in Dhading district. The table 2.4.a shows top 10 varieties categories under cultivated area and quantity of production. The data reveals, farmers produce 12,416 metric tons of tomatoes in in 776 hectare with 16 yields, and radish seems to be another vegetable with high productivity with 14.50 yields.

Dhading ranks fifth for vegetable production among 77 districts (Dhading district profile). In Dhading 66.18 percent of males and 87.16 percent of females engaged in agriculture (CBS 2011). There is zoning of commercial pocket in Dhading district Benighat and Charudi for off-season vegetable (key informant interview, Agriculture Knowledge Center, Dhading).

Table: 4.2.1 Top Ten Fresh Vegetable Production in Dhading, Fiscal year 2020/21

S.N	Commodity	Area (ha)	Production (Mt)	Yields (Mt/ha)
1	Tomato	776	12416	16.00
2	Cucumber	580	8816	15.20
3	Cabbage	565	8192	14.50
4	Peas	551	3078	5.59
5	Carrot	506	3325	6.57
6	Cauliflower	495	7029	14.20
7	Bottle guard	345	5175	15.00
8	Bitter guard	288	3460	12.01
9	Radish	280	4060	14.50
10	French beans	270	2360	8.55

Source: MoALD 2022

* Area in hectare (ha), Production in Metric Tons (Mt), and Yield Metric tons/ha

In Dhading fruits such as; apple, walnuts, orange, sweet orange, lemon, pears, apricot, lime, pomelo, mango, guava, banana, pineapple, and litchi are recorded in the national statistical information (MoALD 2022).

Table: 4.2.2 Top 10 Fruits Production in Dhading District, Fiscal year 2020/21

S.No	Commodity	Area (ha)	Production (Mt)	Yields (Mt/ha)
1	Pears	260	2295	9
2	Mango	251	1566	7.6
3	Banana	150	1378	11.02
4	Litchi	320	1200	10.5
5	Lemon	164	948	8.32
6	Lime	90	477	9
7	Mandarin	326	302	10.44
8	Sweet orange	25	160	8
9	Pineapple	15	150	16.7
10	Pomegranate	300	120	6.7

Source: MoALD 2022

4.2.2 Study Area Cropping Pattern

In the study area, the respondent farmers explain they ranked rice as the first priority crop who have low irrigated land for self-consumption, maize as second for self-consumption and for livestock feeding, and different types of vegetables cultivated in upland for self-consumption and surplus selling. Thus, most of the responses are following;

a. Paddy/legumes-Vegetables(cauliflower/cabbage/leafy vegetable/garlic/onion/peas)-potato
b. Maize/beans/pumpkin/cucumber/bitter guard/lady's finger/squash-potato

In early spring (April-August) the farmers produces cucumber, green pumpkins, eggplant, beans, sponge guard, bitter guard etc. While in winter, the farm is full with seasonal crops such as potato, onion, leafy vegetables, garlic, and wheat. The cropping choice and cropping pattern depend upon the landscape of the farm. Maize is second staple food of Nepalese and ranked after rice in terms of production and area coverage food, feed and fodder grown during the summer season April to august. The farmers are well informed about the mixed cropping system as it

has been practiced from generation to generation. The mixed farming relates to cultivation of two or more crops together in the same field at same time. The crops are seen as friends and do not affect one another in growing and fruiting. The selection of crops is based on nutrient, sunlight, support, root pattern, water required so carefulness and knowledge is required while selecting and cultivating different crops in the same field. The wrong selection could destroy both crops, so usually they are sister crops. For example with tomato, cauliflower and leafy vegetables like coriander board mustard leaves can be cultivated together and in a maize field, beans, pumpkin, cucumber, and soya can grow together nicely (Interviewee Gajuri).

During the field visit, it was observed that the farmers are content with the mixed cropping system. The farmers say, "We can take benefits from the same cultivation with the same inputs such as fertilizers, water, labor and care at the same time. Other things we can earn even if we could not make profit from one crop then other crop profit will cover our expenses. So to be on the safe side we have to do mixed farming and it is continued by our father and grandfather and we farmers are experienced with plant companions. In olden days, our father and grandfather used to prefer mix farming with a concept of self-sufficiency but now, we are doing it for minimizing economic risk. For small farmers like us, this mixed cropping is better as it provides regular income because of varieties of crops growing at the same time with or without different harvesting dates. The farmers can earn quick cash from one crop, for example, the pumpkin while maize keeps on growing in the farm and the land space is used more efficiently. Therefore, it ensures a regular supply of food during the entire year, and is supposed to have cash income from selling the surplus crops in the market (Interviewee Galchi).

Another interviewee (Gyneswore) expressed, "I could not sell my eggplants (brinjal) in the market because of the low market price, and the market price was so low that I would not be able to get harvesting labor cost and transportation charge so I left all the brinjal in the farm for manure. I lost around NRs.50,000 from the brinjal this year. However, just after one month, I am selling beans at a very good price. Therefore, mixed cropping is good for small farmers like me." Here, both economic risk and risk of losses are found low from mixed farming, Poudel (2016) states that mixed cropping act as a 'biological crop insurance' for the farmers because when one crops fails due to insect pest or destruction from drought, hailstorm and any other reasons, then other crops compensate the loss.

Mixed farming includes multiple cropping and mix cropping (not follow row pattern) includes improving soil fertility; reducing the risk of crop failure (Dahal 2010). In mixed farming

farmers cultivate crops along with livestock raising on the same land and the land space is used more efficiently. The farm acquires regular income to the farmers because the varieties of crops are planted in different time period with an intention to harvest at different times. The mixed cropping has an advantage of controlling soil erosion as different crops provide different forms of vegetative cover to the soil, reducing pest infestation (Poudel 2016). For example maize provides shade and support to beans and soya.

4.3 Research design

O'Leary (2017) states that the qualitative approach is popular in social science research due to having the advantage of knowing and exploring the people's understanding, experiences, and practices in the society. This research is exploratory in nature, and not grounded in existing theory as it aims to understand a situation and issue on postharvest losses in horticulture (fruits and vegetables), and the role of farmers and the state in loss reduction. Based on the nature of this research aims and research questions, the qualitative methodology is suitable. In this research, interviews with the farmers allowed me to explore the farmers' perceptions about food loss, and pre-existing practices during postharvest loss of fruits and vegetables prior to sales on the market and consumption. The qualitative research methodology is used to explore the answers to the research questions. The local farmers' personal experiences, opinions and perspectives about the reasons for fruits and vegetables losses, and how their local knowledge and practices are important for loss minimization may not be easy and effective to explain through quantitative methods. The selection of qualitative methods in this research may be appropriate because the analysis is not encircled; rather it is open, and possible to include interviewee's thoughts freely. I found most of the studies, and literature reviews on food loss in post-harvest are studied in agriculture science, and found that researches are analyzed through quantitative methods with statistical analysis that missed the farmer's perceptions in the descriptive forms. Therefore, I am encouraged to do direct interviews and further analyze the research findings through a qualitative approach.

This method gathers the opinions of the local farmers and documents their knowledge, skills and practices used to handle harvested fresh fruits and vegetables for self-consumption and for income gain through selling surplus in the market. Observation will be my research strategy for observing and gathering the general overview of the farmers' practices regarding postharvest management that could help to identify causes of food loss.

4.4 Collection Procedures/ Selection and Access

The research, literature, reports, documents and news are the source used to identifying the ‘food loss’ as the major issues among the farmers' challenges in Nepalese agriculture. Purposive method was used for the selection of the government departments, postharvest loss officials, experts, farmers’ associations and their representative with an intention to gather their opinions on where and why actual postharvest losses are occurring in fruits and vegetables, and to know the study field, and targeted interview participants. Being born and educated in Nepal, having a keen interested and previous work experiences in the nonprofit sector of this country give me an advantage in identifying contemporary issues in the agriculture sector of Nepal. The electronic mails are the source of communication I used for contracting key informants (government officials and farmers representative associations) before field visit but it took me a long time to receive responses. Further, personal networks were used for identifying the concerned person and the organizations with an assumption of easy ways to approach the respondents. A young farmer, the winner of best vegetable producer 2022 of Dhading was the first interviewee of this research. The interview went nicely and helped me to understand the overall current scene of the vegetables production, problems and challenges of the farmers in Dhading. The respondent suggested visiting the Prime Minister Agriculture Modernization project (PM-AMP) for further information regarding government programs and support in agriculture sector modernization and development in the district. Next day, an appointment was received with the director of PM-AMP at ‘Dhading Besi’, the headquarters of Dhading. Key informant interview guidelines were found worthwhile for the conversation with the project director on the topic postharvest losses situation, and government current activities to address the problems. Receiving the lists of farms, with farmers’ name and contact number existing in the district was beneficial to contact the next farmers as the respondents. Meantime, in the PM-AMP office space, I received an opportunity to interact with a young farmer, a manager of a farm located at ‘Gajuri municipality’ of Dhading. After a simple conversation and explaining my purpose to visit, his eagerness and readiness for participating in the interview energized me for the interview. Further participants were contacted through the lists and snowball method. The Snowball method is found to be an appropriate method to select the farmers who are involved in agriculture for self-consumption and for commercial purposes. The fieldwork was conducted during January, the winter month in Nepal. The time is suitable because farmers have already harvested, sold and stored the remaining main cereal crops (rice,

millet, wheat, and barely) and vegetables farming farmers get ready for cultivating and harvesting winter vegetables. October to January months are winter in Nepal so, to observe the harvest of winter fruits and vegetables (such as orange, sweet orange (Junar), lemon, indian gooseberry, cauliflower, broccoli, cabbage, spring onion, garlic, pepper, chilly, tomato, mustard, radish, carrot, peas, faba beans, turnip etc), leafy vegetables (fenugreek, spinach, coriander, board leaves mustard) is interesting. However, it could be more informative when I was able to observe a full year vegetable cropping calendar. Generally, in the hills and terai parts of Nepal, due to geography, environment and suitable climate, the vegetables are grown all year round. The agriculture department has categorized summer vegetables, monsoon vegetables and winter vegetables. The Ministry of Agriculture and Livestock Development (MoALD) statistics of agriculture recorded 60 different types of vegetables commercially grown in Nepal but there could be more, because small amounts of local vegetables grown for household consumption are not all documented in national statistics.

4.6 Types of data (Primary and Secondary)

Based on this research topic and the purpose, the data and information are derived from both primary and secondary data. Kitinoja and Kader (2015) state, data on postharvest losses generally collected either via surveys/interviews or via sampling/direct measurements. Direct interview as a primary source of this study helps to accumulate the farmers' farming experience, hardship and upcoming challenges that is put into comprehensible facts in the study.

4.6.1 Interview

The primary data sources will enable us to get answers to the research specific questions that require further analysis. Field level households' interviews were conducted with semi-structured questionnaires with 10 local farmers. Beuving and Vries (2015) state, that before the interview, researchers have to know who the participants are, whether they are appropriate respondents to the research questions, and what to ask about the topic. Therefore, for selection of the interviewee, I did consultation with members of the farmer group, government officers, and personal network. The published online daily newspaper news is a source to identify the orange fruit farmer of the study area. The news published success story of the farmers in

gaining more income from the orange farming. Variation in age group and gender considered while selecting the participants with a hope to gather different perspectives and experiences. Therefore, a purposive method was applied in interviewees' selection in this research. The lists of interviewees presented in table 4.6.1

Table 4.6.1 Lists of participants

Farmers categorize	Age/Gender	Address	Number
Vegetables	40/M	Galchi Rural municipality-2	1
Vegetables	66/F	Galchi Rural municipality-3	1
Vegetables	39/F	Galchi Rural municipality-3	1
Fruits and vegetables	52/M	Galchi Rural municipality-2	1
Vegetables	38/M	Gajuri Rural municipality-2	1
Vegetables	31/M	Gajuri Rural Municipality-3	1
Vegetables	46/M	Gajuri rural municipality-3	1
Fruits	51/F	Rairang rural Municipality-10	1
Fruits	58/M	Rairang Rural Municipality-10	1
Fruits and Vegetables	62/M	Rairang Rural Municipality-9	1

Source: Field Visit, 2022

All interviews conducted face to face in the field only after the interviewee's consent because some participants might not want to have the conversation without any particular reasons. Semi-structured questionnaires were prepared and used for interviews because it will guide the researcher to concentrate on the theme, and participants could feel comfortable in answering what they asked. The semi-structured questionnaires beginning with the socio-economic background allow to build up a smooth relationship with the participants. In Nepalese society,

after greetings “Namaskar or Namaste " usually it is common to ask *“Sanchai hunuhuncha?"* It means “how are you” in Nepalese. It is fine and welcoming to begin the conservation by asking name, age, address, and the family members’ background. It is a rapport building process. In general, I prefer note taking rather than following one by one questions to flow the conversation. Note taking is a good tool and effective to review and fulfill missing parts of the interview data and information. The informal interview practice is welcoming from the local farmers with its flexible nature so, sometimes the conversation goes in different directions. However, I tried to center on participants' awareness and handling practices of the postharvest produce, and the factors causing losses. The farmers' awareness level and preservation practices is important and the starting stage for losses minimization (Ngubo 2021). During the interview process, the participants were cooperative and happy to share what they know and how they are doing farming and handling the postharvest produce. The interview taking time varies morning, afternoon and sometime evening with considering and valuing the farmers’ precious time. However, all the interviews were conducted on the farm.

4.6.1.1 Socioeconomic Background of the Respondents

This research set out to identify the causes of postharvest losses on fruits and vegetables, and to explore how the smallholder farmers’ traditional knowledge and practices are helpful for handling the postharvest that contribute in loss minimization. The numerous postharvest scholars (mention the socio-economic determinants is also a factor for the postharvest loss because the resource poor smallholders could not afford the advanced technologies and take risks. The demographic and the socio-economic characteristics respondents supposed to determine the farmers Age, Gender, Family Size, Education, land holdings, professional background, Income Source knowledge, training and the respective postharvest handling practices and to establish the determinants of vegetable postharvest losses among the smallholder farmers. The socioeconomic background of the respondent smallholder farmers is presented to provide overview of the farmers and their potentiality to undertake postharvest loss reduction techniques and technologies.

4.6.1.2 Demographic and Socio-economic Status

Table 4.6 Demographic features of the Respondents

Variables	Categories	No. of Respondents
Gender	Male	6
	Female	4
Age	20-40	3
	40-60	5
	Above 60	2
Education	Literate	2
	Secondary	2
	Higher secondary	4
	Above Bachelor	2
Family Members	Less than 5	2
	5-7	5
	Above 7	3
Professional Background	Farming	5
	Farming and Service	4
	Farming and Business	1
Land ownership	Less than 0.5 ha	1
	0.5 to 1 ha	9
Income Source of the households	Only Farming	5
	Farming and Remittance	5
	Farming and Service	4
	Farming and Business	1
Training	Government	10
	Private (I/NGOs)	8
Members	Farmers group	10
	Mothers group	4
	Cooperative group	10

Source: Field 2022

4.6.1.3 Age

The income from subsistence farming is not enough for livelihood thus, usually the family members have to involve in alternative jobs. Usually, young members go for either foreign employment or join service in government jobs (police, army, school and service). After the retirement age, most people preferred farming jobs when they came back to the village for their own purpose. At the old age with a low education level, usually they do not prefer to invest and do business. However, the surplus produce is being sent to market for sale. Low education level and low level of understanding of information and technology, the farmers could not respond to the opportunities (training, credit and funds), and improved productivity as the young commercial farmers could do, which results in low agricultural production and low productivity. The old farmers could not easily adopt new ways of production that would enhance productivity and minimize postharvest losses.

4.6.1.4 Education level

According to Dhading District Profile, the literacy status is above 50 percent in Dhading. Garikai (2014) study concludes that the farmers' education level is significantly influenced in adopting new technology, access to credit and supports required for affording postharvest technologies for loss reduction. The young and educated respondents (Gyaneswore and Nabin) seem to be aware and informed about the market demand, market price, and subsidy from the government. They have participated in various training and programs provided by the local government, municipality, district agriculture office, agriculture knowledge center, project (Prime Minister Agriculture Modernization Project, Value chain development project), and cooperative. Credit access from the cooperative and bank make it easy for them for further investment in farming.

The farmers or producer's level of understanding of consumers' demand and quality preference is essential so that the farmers would produce and supply the desired produce and compete in the market (Garakai 2014). Therefore, education is essential to understand the consumer's preferences and quality (Garakai 2014) and to know about the postharvest handling of the vegetables (Azad et al.2014). The farmers with low education have limited access to information regarding market, price, consumer's demand and expectations, identifying new

markets of the produce. Azad et al. (2014,11) claim, the education level of the farmers has less contribution of their knowledge on vegetables postharvest practices like other factors; farmer's experiences and training on vegetable cultivation however, the study concluded, the higher the education level of farmers, higher the knowledge on postharvest practices.

4.6.1.5 Professional

The respondents were from the farming family background, and have been farming for generation. In the study area, the majority of the respondents are fully involved in agriculture but some respondents are also involved in service (government employee, agriculture trainer, cooperative employee, vegetable collection center) and business (small shop) along with farming. All the respondents state 'the farming job is difficult that needs hard work and more dedication, but the income earning is very low and insufficient for children education and for buying advanced agricultural tools for commercial farming. Thus, for extra income, most of the farmers do additional jobs and some of the respondent's family members have gone for foreign employment mostly in Gulf countries, Malaysia, and some European countries.

4.6.1.6 Land Ownership

The interviewee landholding size ranges between 0.5 ha to 1 ha that includes two types of land; lowland (Khet) and upland terraced (bari). The lowland is mostly irrigated and use for cereals production whereas upland is rain-fed and suitable for less water-intensive productions (Dahal 2010). The larger landholdings of the farmers are supposed to determine from the farm income with an assumption of surplus production, reduce cost of production, and expected earnings (Garakai 2014). The large farm size with fewer family members has to hire labor for cultivation to harvest and handle produce that generate employment and simultaneously the costly labor charge increases cost of production and decreases profit margin of the farmers. Two types of agricultural lands, irrigated lowlands (Khet) and rain-fed upland terraced lands (Bari) were found in the study area. Lack of Irrigation is the most challenging factor for the farmers to increase vegetables production and productivity, so many land are left barren, and produce is not marketable quality (Benighat Rairang respondent).

4.6.1.7 Income Source

In the study area, income diversification of the farmers for livelihood was observed. The smallholder farmers were involved in different activities along with farming. The farmers whose income source is only farming were also raising livestock including cow and buffalo for selling milk, goat and chicken for meat. "In past days, farming used to be only source for livelihood but along with time, farmers have to involve in different sectors for earnings. In the village, the foreign employment has attracted young generation and become supporting income source to every household." (Respondent, Gajuri). Some farmers were also involved in service besides farming. The farmers' additional various income source and overloaded schedule could be the reason for farmer's lack of time in farming and marketing of the produce. (Field observation farmer's daily routine).

4.6.1.8 Training

Training capacitates the individual in generating idea in cultivation, harvest handling and management, and marketing the produce. Almost all the respondents have participated in different training provided through local government (municipality, ward), district government, district agriculture office, agriculture knowledge center, government and non-government projects, cooperative and Small farmer micro finance. The trainings in which the respondents participated trainings includes; agriculture improvement training, marketing training, farm management training, picking, packaging , postharvest handling of fresh produce, storage management, seed management, nursery management, postharvest management extension,

4.6.1.9 Access to Loan

The respondents prefer to take loan from the informal sector at high interest rate because of lengthy and complicated process. Now, due to numerous cooperatives and microfinance service in the rural, the loan accessing loans for farmers are easy. Lack of financial literacy, the rural smallholder farmers are not able to manage finance properly which creates financial problems to the farmers.

4.6.2 Key Informant Interviews

Thomas (2013, 145) states, "viewing from several points is better than viewing from one". The divergent perspectives of the informants facilitate me to understand and analyze the postharvest losses occurring factors and ongoing activities from different angles. The key informant's interviews are the important sources of knowledge that support my level of understanding regarding the problems, study area, and for information collection that could not be available online. In this research, the government officials of the horticulture department, farmers' commission information officer, Project manager of the Value Chain development of Fruits and Vegetables Project (VCDP), Agriculture knowledge center officer, Dhading, representatives from the smallholder farmers associations, and farmers' group members, and Prime Minister Agriculture Modernization project director of the respective districts are the key informants. The lists of Key informants are presented in table 4.6.2.

Table 4.6.2 Lists of Key Informants

S.N	Key Informants	Organization
1	Director, Dhading	Prime Minister Agriculture Modernization Project
2	Agriculture officer, Dhading	Agriculture Knowledge Center
3	Agriculture Extension and information officer, Kathmandu	National Farmers' Commission
4	Senior Postharvest specialists, Lalitpur	MoALD department
5	Program manager, Kathmandu	VCDP of Fruits and Vegetables Project
6	Director, Kathamndu	Kalimati Fruits and Vegetable Market

Source: Field Visit, 2022

4.7 Observation

As Nygaard (2017, 143) states, observation allows the researcher to focus on what the participants are actually doing in day-to-day life, and interviews provide information on what they thought, experienced, and practiced. Beuving and Vries (2015) also express that

observations provide a great change for the researcher to get closer to the participants and society that are going to study. Therefore, to observe people and their everyday practices applied in postharvest handling could be an interesting and informative part that this research will consider in the observation method. The 'photos' taken with consent during the field visits are the recording sources of this research observation. Opportunity to stay in the interviewer's home was grateful and beneficial for me to explore farming practices and management of the harvested produce handling.

4.8 Secondary Data

Secondary data, the significant source of data and information to know the background and issues in the subject matter, and to select the study areas. It is important to study what the government policy and program are for horticulture development and how they are supportive for addressing the issue of postharvest losses in Nepal. In this research, the agriculture sector prioritized State's periodic plans, the ongoing national fifteenth periodic plan (2019-2024), Agriculture Development strategy (2015-2035), horticulture development policy and project documents, are collected and reviewed to documenting the government roles in fruits and vegetables development specially, the postharvest losses minimization. The Central Bureau of Statistics Office (CBS) is the main source to access national statistical information and data in Nepal. The topic related published documents and reports that were not available on the internet are collected during office visits for conducting key informants interviews. These resources help me to understand the current situation and challenges of the Nepalese agriculture sector specially, the progress achieved and challenges in the fruits and vegetables sector. The published journal, articles and recent news were relevant for this research to point out several aspects and insights around the theme of the research, and to provide direction in analysis.

4.9 Research Analysis

In this research, inductive thematic analysis will be an appropriate approach as this research purpose is to analyze farmer's perceptions, opinions, and existing knowledge, and experiences applied in postharvest handling. Direct interview and conversations with the farmers regarding their agricultural life, knowledge, experiences, views, opinions about postharvest losses, their roles, and the government support, I believe the thematic analysis is appropriate for analyzing

subjective information of this research. Creswell and Guetterman (2021) described 'hand coding' technique is used to gather and organized the information received from the respondents and the key informant interviews. The chunks of key informants' responses were classified as different themes into group and sub-groups. The themes were presented in appropriate sections to validate the explanations and connect with the postharvest loss, its causes and the farmers and government strategies for reduction. GC and Hall (2020) findings presentation, and analysis technique is followed throughout the findings discussion, and analysis chapter.

4.10 Research Ethics, Positionality, and Reflexivity

The study has received approval from the Norwegian Center for Research Data (NSD) to proceed based on NSD guidelines. While considering the ethical issues like in every research, first the smallholder farmers involved in fruits and vegetables farming who are able to sell some portion of surplus produce in the market are consider. The interviews personal data and information were anonymized. For example; the respondents' real identity were hidden and presented as pseudonyms in this study. The consent was taken from the participants before the interview begins, and the interviewees were not bounded to stay beyond their interest. Most of the interviews were conducted in the farmers' field in Nepali language for farmers comfort but I keep note in English. Some Nepali words the respondents spoke was quite difficult to translate in exact English meaning so, synonyms of that word were written. The research topic is not sensitive with simple interview questions that are related to day to day life of the farmers and their perspectives on farming, their knowledge and practices that are shareable. Therefore, the respondents had not hesitated to have conservation and note taking while interviewing.

During the research, at first I struggled to get cooperation from the some key informants when I disclosed myself as a master student. Later on, I was welcome and supported, and able to receive required information for my study after explanation of my purpose. Some informants who were familiar with the University of Oslo, Norway curiously asked about my course and thesis topic. The respondent farmers all were very supportive and cooperative. I got chance to live in one of the respondents home as a guest and able to observe the farmers livelihood, farm and farming practices closely. One of the farmers thought I belong to news reporter and came for reporting because he had given some interviews for the news. Entire interviews, I tried to

get the respondents perspectives based on my research objectives in an informal way just like simple conservation. I made an effort to show unbiased nature during the data collection and data analysis through presenting all the respondents' and key informants' opinions. However, as a researcher biased view, some of the respondents' perspectives are more prioritized and presented to justify the research questions.

4.11 Limitations

The agro-ecological climatic condition makes Nepal suitable for year-round cultivation of fruits and vegetables in hills and terai area. The fruits and vegetables production areas and the farmers are scatter all over Nepal. The short duration limits to cover large area and number of respondents. Dhading being a vegetable pocket zone area and almost 20 to 25 percent capital city Kathmandu demand is fulfill from the Dhading district. Therefore, Dhading as a study area is purposively selected. The small sample population is not sufficient to represent the whole sections of the farmers' society and generalization is not applicable. However, this research attempts to present the farmers perceptive from the ground level about the postharvest loss causes and the smallholder farmers' strategies in handling the situation to minimize the loss percentage. On top of this, the key informants' information was quite helpful to know the situation and government activities in postharvest loss reduction sector.

Chapter 5: Findings and Discussions

5.0 Introduction

The chapter findings and discussions comprised enormous primary data and information that gathered during the field visit. The historical farming overview of mid hills revealed, cereals crops as the main production crops. Nevertheless, the fruits and vegetable farming have substituted the cereals crops simply because of profitability and other reasons are mentioned. Moreover, along with increased vegetable production, the farmers are facing challenges of vegetables loss after harvest due to numerous behind that includes postharvest handling and management practices, climate change, labor shortage, market access and government minimum support price are identified and discussed. The presentation of smallholder farmers' thoughts and ongoing farming practices that is transferred from generations has tried to explore the main research question of farmers' strategies in postharvest loss reduction.

5.1 Farmer's attraction on Fruits and Vegetables Farming (Farm registration trend)

The Food and Agriculture Organization (FAO 2016) data reveals, Asia is progressively leading in fresh vegetables production. Production wise, Nepal ranked sixth position in vegetable production after China and India. Vegetable farming is one of the sub-sector of agriculture (Shrestha et al.2022), and main source of income and better livelihood of the farmers (Rai et al.2019). Vegetable farming is a traditional farming practice (Rai et al. 2019) and 'a way of life of the rural farmers' beyond economic gain (Ghimire et al.2018). The number of vegetable growers is increasing significantly due to high market demand and profitability (Pandey and Shakya 2016; Rai et al.2019). Increasing demand trends of vegetables and the high production possibility emerged several programs for promotion of commercial vegetables (Ghimire et al. 2018). The agriculture statistics report of Ministry of Agriculture and livestock Development (MoALD 2022) shows, vegetable farming in Nepal is getting attraction to subsistence farmers, commercial farmers, and the business firms, till 2021, there were more than 3.2 million farmers involved in vegetable farming. The vegetable sector has provided self-employment to the farmers and numerous employment opportunities to the value chain actors including input suppliers, collectors, transporters, agriculture laborers and businesspersons (Shrestha et al.2022). Rai et al.2019 claim that apart from employment, in a short time the farmers are

successful in generating cash even from a small plot of land thus, farmers are shifting form cereal crop farming to vegetable farming.

One of the respondents of Galchi expresses, “We are happy in vegetable farming. We used to cultivate cereal crops in our land before 5-6 years, at that time we could only feed our family for 6 months and the rest of the months, we had to do off farm activities. We have to go to the city in search of work where we find construction labor jobs on an hourly basis. Now, following other farmers and training, technical support from the government, we are now producing vegetables and able to sell at a good price. The income from the vegetables is good enough for household expenses and for children's education”.

This response indicates, crop diversification is found beneficial to the farmers in terms of income gain. GC and Hall (2020) study findings identify vegetable farming is popular among the several foreign employment returnees after realizing to earn money in the gulf country as unskilled labor is difficult, vegetable farming possess higher commercialization possibilities, and profitability. Short crop cycle of the vegetables, good profit margin, small initial investment possibility, and quick investment return from selling the produce are major attractions of vegetables farming among the interviewee farmers. The organization supports project, programs that are high in hills and considered as the reason for promotion of vegetable farming in hilly areas (Devkota and Mishra 2020).

Most of the respondent farmers prefer seasonal vegetables because they think it is easy to cultivate, no need for extra care and inputs whereas for growing off-seasonal vegetable additional investment in tunnel, special pesticides and chemicals are need. The farmers view they lack knowledge and techniques in growing off-season vegetables. Hence, most of the respondents do not want to take risk and invest in off seasonal vegetables even though there is probability of more gain.

5.1.1 Vegetable Crops Preference ranking

Produce high yield, short maturity time, high commodity price and less cost of production, less percentage of loss, market demand and market distance are the factors that farmers calculate while selecting the crops for cultivation. Based on interviewee, farmers’ estimated loss

percentage, the loss ranking is calculated. The interviewee farmers responded, “the farmers preferred to grow leafy vegetables because it grows very fast and ready for sale within a month and the market value is not so fluctuating like other vegetables. Other things, leafy vegetables being most delicate, the farmers prefer to sell in the local market and remaining can put for fermentation for future consumption. Due to quick sale the farmers can collect money quickly”. One of the respondents of Galchi said, “even though I make a loss on brinjal this year due to low market price, but I will continue cultivating next year, because the production and yield is high in brinjal likewise in bottle gourd, bitter gourd and pumpkin, and less care is enough than tomato”. Thus, farmers' crop selection is also dependent on the high yield, high production, and less resources (human, water, manure, pesticides) needed to grow crops.

Table: 5 Vegetable Crops Preference ranking with Loss percent and reasons of Loss

S. N	Preference Commodity	Guess Loss Percentage (%)	Loss Ranking (%) based	Reason of loss
1	Leafy vegetables	5-10	6	perishable nature, rain
2	Radish/carrot	5-10	6	unable to sell in market
3	Beans and cowpeas	0-5	6	excess production
4	Cucumber/Squash	10-15	4	low market price
5	Brinjal	30-40	1	low market price
6	Cabbage	20-30	2	excess production and low price
7	Cauliflower	20-25	3	low market price
8	Bottle Gourd	5-10	6	excess production, lack of market
9	Bitter Gourd	15-20	4	excess production, low market price, disease
10	Tomato	10-20	5	low market price, labor shortage, disease

Source: Field visit, 2022

The above respondent farmers information reveals that the farmers lost large percentage of loss on their produce due to various reasons. The most of the reasons are due to low market price, excess production, labor shortage and disease. Generally, the farmers feed the excess harvest produce to the livestock that are unable to sell in the market, some left in the farm for manure that is not edible for livestock. In general, term agricultural produce lost after harvest is postharvest loss. While interviewing with the farmers in the study field, the farmers think differently. The majority of the respondent farmers express, "actually there is no postharvest loss because the agricultural produce if not consume by the human then it could be feed to the livestock. So, there is no loss and postharvest loss because our hungry livestock can eat. However, there is economic loss because farmers could not get cash by selling the produce in the market. But if the harvest produces are not in good condition in quality wise and even it could not give to the livestock and if thrown away as waste then it is called postharvest loss". The farmers understanding on postharvest loss is different than the definition of FAO which define postharvest loss as the loss of food produce for the human but never consumed by the human due to many factors such as postharvest handling practices and postharvest management.

5.2 Postharvest Loss, Postharvest Handling Technology and Postharvest Management

In developing countries, traditional methods of harvesting, tools used, storage, packaging, transportation and handling techniques causes postharvest loss. Feqeerzada et al (2018) claim smallholder farmers are not able to afford postharvest technologies and infrastructure due to high installation cost at starting, and practice traditional postharvest technology that is the reason for fruits and vegetables losses in the South Asia countries. The lack of appropriate infrastructure, capacity, technology, knowledge gap, limited transportation and inefficient logistics are major concerns of food loss in developing countries (FAO 2017). The postharvest handling includes various activities; harvesting, processing (Adhikari and GC 2021; Feqeerzada et al.2018).

5.2.1 Postharvest handling practices in the study area

Within the value chain, the smallholder farmers' adopted postharvest handling practices have significant results on postharvest loss (Kumar and Underhill 2019). Careful harvest handling is necessary measures, and harvesting in the early morning and evening is significant for reducing mechanical injury (Workinch and Lemma 2020).Thus, research focuses on identifying the smallholder farmers' awareness on postharvest loss and ongoing harvest handling practices.

5.2.2 Harvesting Time

Properly and timely harvest of the produce has significant effect on the produce that could save from mechanical, physiological and pathological losses (Adewoyin et al.2022).The interviewed farmer expressed "the harvesting or picking time depends upon the nature of the products and the temperature in the farm. However, the available and suitable time of the farmers, the collectors, laborers, and the distance to the collection center and market determine the harvesting time". The harvesting time is the most important factor that needs to be considered in postharvest Awan et al. (2012).

The interviewed farmers of Galchi explained, "The harvesting appropriate time depends upon the produce type. For example, leafy vegetables should not be harvested in the morning due to wetness in the farm field that damages other crops from different diseases, and the harvested leafy produce wither quickly in the afternoon. In summer, season early morning (6 to 9) am and (4 to 6) pm whereas in winter (8 to 11) am and (3 to 5), pm cool time of the day is suitable but due to family member migration for employment and labor shortage in farm, the hired labor is difficult to find and usually work in daytime. The collector picking time is also after 3 pm so harvesting is done during the day". The above-mentioned expression may state that even the farmers are concerned about the appropriate timing for harvest but due to labor availability (on a daily basis in the daytime) and the market distance, the harvesting is done in the afternoon. The daytime harvested products contain more farm heat that maximizes the loss percentage (Khatiwada and KC 2022; Kumar and Underhill 2019). According to Adhikari and GC (2021) during the respiration process of the produce 'the heat is produced as a byproduct', carbon dioxide (Co2) and improper ventilation could result in the fermentation process and deteriorate

produce. The farmers' committed time for ready to pick up to the transporter or collectors depending upon the markets distance also governed the harvesting time in developing countries; usually afternoon harvest of the produce for long distance market while, the evening time is used for the morning local market (Awan et al.2012; Khatiwada and KC 2022). Thus, temperature is found to be a significant factor for perishable produce, and moderate temperature is necessary to maintain for increasing the shelf life.

5.2.3 Harvesting tools and containers

The respondent farmers preferred manual harvesting with using traditional farming tools include; sickle, hoe, spades and cutting knives that need human power and hand to use. "The Prime Minister Agriculture Modernization Project (PMAMP) 10 years project is under implementation from 2018 with an objective to modernize the agricultural sector and has been providing subsidies in agricultural tools and machinery. "Most of the farmers in Dhading use plastic crates for delicate perishable such as tomatoes and oranges. The popularity of subsidized plastic crates has replaced the traditional bamboo basket (DOKO) in Dhading has lowered the loss percentage" (Key informant PMAMP Dhading).

5.2.4 Harvesting technique

During the field visit to the Galchi respondents farm, it was observed that the farmers and other hired labors were following traditional method of hand picking vegetables without using gloves is observed in Galchi respondent farm. Shaking trees to drop down fruits as in past is not in practice for orange harvest in Benighat Rirang field visit. "We are much aware and learnt how important the harvesting phase is from the training provided by the government, so we usually put bamboo ladders to reach up to the fruit for picking but using gloves while picking fruits and harvesting vegetables is not workable for us. The gloves are not easily available and we do not have practice in using them (Interviewee, orange farmer, Benighat Rairang). The majority of the interviewee farmers expressed due to overload and multiple tasks and responsibilities they hired labor for harvesting produce on per hour or on a daily wage basis. The hired laborers are not always good and trained but we do not have an option due to labor shortage in the village. "The labor's careless handling is causing loss but we have to ignore a certain amount of loss" (Interviewee, orange farmer, Benighat Rairang). All harvested produce for example

cauliflower, cabbage, brinjal, tomato are heaped in the shade to protect from direct sunlight. Cleaning root vegetables for good appearance is necessary, the consumers' choice of cosmetic appearance of produce is increasing loss (Interviewee, Galchi).

5.2.5 Precooling and Temperature Management

Precooling is another important process of the postharvest handling that farmers need to practice. The Pre-cooling method is not seen in the study area. The harvested produce is left in the shade area that is usually under the tree. The farm heat has to be maintained to maintain temperature and reduce loss (Adhikari and GC (2021). Precooling can increase shelf life waiting 3-4 hrs from harvest (Pokhrel 2010). The tradition of spreading and leaving harvested produce without overlapping and in the open sky overnight to chill and maintain freshness was observed. This method was found significant during the night, it is mostly cooler and fresh air is a natural coolant. The products are sold in the local market the next morning. Temperature management of the product is a significant factor to increase shelf-life which can be done through various treatments such as low temperature, heat treatment, drying, hot water, vapor, hot air, radio, and irradiation (see;Workinch and Lemma 2020).

5.2.6 Sorting and Grading

The interviewed vegetable growing farmers commented, "even though we have shortage of time and multiple work burdens, cleaning, and sorting vegetables before packing for transportation to collector or collection center and storage is a compulsory task. The produce without sorting is less valued and sometimes rejected from the collectors and returned back, which is loss. The sorting process is manual and done by hand. It takes significant time for the farmers but after that we can negotiate for the price which is good". Sorting is a necessary process so we have aware and trained farmers on postharvest handling but some farmers' ignorance and carelessness is problematic for pricing, and the poor quality can damage the whole produce (Interview, respondent, collector). The research of Kumar and Underhill (2019) found 'sorting' is an important postharvest handling process that farmers need to follow because of recording different percentage of loss in the value chain that does not follow pre-storage sorting process. The respondents farmers seem aware of the sorting process and separate on the basis of quality and size in particular produce only but sometimes they do not

that could be a lack of time, whole sum price of all produce. Grading of the produce was manual, which is done, based on color, size, appearance, texture, ripeness, and perishability that was observed during field visit.

5.2.7 Packaging

Proper and smart packaging maintains food safety and quality (Kaini 2019) protects produce from physical damage, mechanical, pathological and physiological deterioration all the way transportation, marketing, and storage (Workineh and Lemma 2020). In the field, different materials are found used based on the market, collector, and collection center. Generally, interviewed farmers use the cheap materials such as polythene bags and plastic sacks are highly used for packing produce less perishable vegetables (cauliflower, cabbage, beans, carrot, beans etc) while, plastic crates, wooden box and cardboard box are used for tomato, cucumber, pepper packaging and transporting for long distance. “Before plastic crates, we used ‘jute sack’ and ‘doko’ for putting produce and sending it to the market. We often put tree leaves of neem, litchi and banana in between the produce to minimize loss from friction damage and rotten but now we hardly used it because of less availability and due to collectors’ suggestion” (Interviewee, farmer, Gajuri).

5.2.8 Storage

The appropriate temperature maintenance in the storage increases shelf life and minimizes decaying of fruits and vegetables. Among different types of storage, that includes controlled atmosphere storage, modified atmosphere storage, hypobaric storage, traditional rustic storage and zero energy cold storage types are used in rural areas of Nepal (Adhikari and GC 2022). Cellar store is also known as zero energy cold storage that is constructed using local resources; bamboo, sand, bricks, straw, gunny bags and has capacity to maintain temperature between 4 to 12 degree centigrade (Bhattarai 2018). The cellar storage is also known as the “Wall-in Wall” evaporative cooling system used to extend the shelf life of produce (Adewoyin et al.2022). “The zero energy storage is suitable in hilly regions where power supply is lacking which is in operation in upper Dhading whereas cool Bot storage being less costly and affordable is popular among small scale producers. Cool storage is very important during summer when the temperature rises to produce safety” (key informant, PMAMP, Dhading).

Some interviewed farmers opined cool storage is needed for commercial farmers who have large amounts of produce ready for sale or for later sale but we do not have such a large quantity of harvested produce for storage. We usually store at home just spreading them on the floor. However, the farmers with surplus produce wish to have access to cold storage because they have to sell produce at a very low price that could not cover transportation charges.

The above mentioned and discussed postharvest loss factors caused by human and have possibility of reduction from careful handling and management of the produce. However, there are other factors identified during the interview such as climate change impact, labor shortage, and market structure that are discussed below.

5.3 Climate change, Cropping Pattern and Food Loss

The Nepal Planning commission strategy and indicator document present Nepal as one of the most vulnerable and highly climate change affected developing countries (NPC 2022). Climate change is a global challenge that has affected all sectors of the economy, including agriculture. Being an agriculture dominant district, the farmers of the study area have also seen the impact of climate change in agriculture. “Delay in monsoon rain makes the land dry like drought during summer, and sometimes sudden extreme rainfall with hailstorm affected the crops and flowers of fruit, increase in temperature also affected crops production and yield, our rain-fed agriculture system is extremely affected from climate change, slowly our cropping calendar is also changing (Interviewee, farmers). Another respondent farmer expressed “I watched on television about how climate change is affecting poor countries. Modern farming and commercialization is not good for the environment and for human health. Our chemical free traditional farming and cropping pattern is good because it does not destroy the soil. Now, I am confused about what is best because in the past we were taught to use chemical fertilizer Urea, diammonium phosphate (DAP) and Potash (muriate of potash, MoP) to increase production. I am thinking of visiting the Agriculture Knowledge Center for consulting with the agriculture office and junior technical- Agriculture (JTA)”.

“The use of hybrid crops and more chemical fertilizer and climate change impact has highly affected Dhading, so we are raising awareness and providing training to the farmers for using appropriate quantity and quality of chemical fertilizers, insecticides, and pesticides. In addition,

we are encouraging farmers to readopt organic farming slowly and use bio-resources instead of chemical fertilizers, and providing training about climate smart agriculture intervention, but it may take some time to understand and adopt. But the good thing is… the farmers have been realizing about the impacts of climate change" (Key informant, AKC, Dhading).

5.4 Labor Shortage

Agricultural labor shortage in the village due to rural to urban migration and foreign employment migration is another hindering factor in the Nepalese agriculture sector. The Department of Foreign Employment, Nepal (DoFE 2014) report on labor migration for employment reveals that after 1990, the trend of youth migration for foreign employment is increasing and estimated 90 percent are from rural areas.

Gyanaswore Lamichane (pseudonym), an interviewed farmer of the study area said, "In my village most of the houses, the young and economically active male members are absent. They have migrated leaving all the agricultural work responsibilities to his parents and wife. In some families, wives of migrated men settle in district headquarters or in Kathmandu for their children's better education; therefore marketing, transporting and selling harvested produce even in the local market is quite difficult for the farmer's family who are old. Migration results in shortage of agricultural labors, and increased labor cost, leaving fruits and vegetables in the farm without harvesting at harvest time. Sometimes the farmers could not get laborers for harvesting and market price is below cost of production then farmers leave the produce in the farm field which is common to the farmers and a major factor of produce loss". The majority of the interviewee, farmers have similar feelings and expressed, "youth do not want to be involved in farming and live in the village. After schooling up to grade 10, the younger generation moves to the capital city Kathmandu for higher education and some prefer to go for foreign employment. The chances of youth returnees in the village who went for education are rarer because they are disinterested in agriculture farming. So, I am afraid who will take care of this land and what will happen after us."

One of the factors for migration could be lack of employment opportunity in the village (GC and Hall 2020) and farmers' frustration from the farming occupation due to low profitability, low productivity, low farm gate price and no government support price policy (Bhattarai and GC 2020). Ownership of small parcels of land for cultivation is not enough for sufficient food

production hence; many households have adopted migration as an option of livelihood strategy (Gupta et al. 2022). Upadhyaya et al. (2022) expressed male rural out migration definitely decreases availability of agricultural labor nevertheless, decrease in agriculture production is not due to migration because remittance can afford labor in the village. In the absence of a person willing to work in the agriculture sector in the village, there is no use of remittance and farmers could not afford more. The Agriculture labor shortage is challenging in rural parts of Nepal that result less progress in agriculture than estimated (Gupta et al.2022). In the study area, it was observed that male members either go for foreign employment or work in urban areas. Most of the rural people migrate in unskilled and semi-skilled visa without receiving proper knowledge about the types of work they have to do. So, many migrants complain about the manpower company for not getting well paid from the company abroad and what is written in the contract. Even though they live in the village with their family but were involved in other off-farm employment activities. The female members are responsible for all the agricultural work. Therefore, women's poor access to credit and resources, information and network, training and exposure, and overloaded household burden do not let her effectively handle agricultural work and handle harvest produce. 'Feminization of Agriculture' sector in Nepal and due to gender roles in the family and society, female have triple work burden Upadhyaya et al. (2022). Nepal ranked top on the women's involvement in agriculture in the year 2021 with a fact that about 70 percent agricultural workforces is handled by women (FAO 2022). Therefore, the agricultural labor shortage is one of the driving factors of postharvest loss as it hamper in timely harvesting and transportation of the produce in the market for sale.

5.5 Market Structure

As mentioned in the article by Kader (2005), roads in many developing countries are often in poor condition and inadequate for use of proper transportation for fresh produce. During two-decade periods some development is seen in road infrastructure still, the South Asian countries face proper transportation facilities so; the farmers and the collectors or the traders use different vehicles depending upon the road condition, and distance to market (Faqeerzada et al.2018). Mostly, the smallholders could not afford to have their own vehicle with refrigerated system for fresh produce transportation (Garakai 2014). In the study area, it was found that the collector, trader and cooperatives provide transportation service to collect harvested produce from the farmers. It was observed that off-road pick up truck 'Mahindra Bolero Pick-up" is

used for transporting fruits and vegetables in the study district. For the transportation service, the interviewee farmers state “they have to pay additional transportation charge on their produce that depends upon the weight and market distance. Mostly, the transportation charge is Rs.5 per kg”. Lacking adequate transportation, general vehicles (without air conditioning) like trucks, jeep, and vans are used for fruits and vegetables transportation from the collection point to the big markets (Khatiwada and KC 2022).

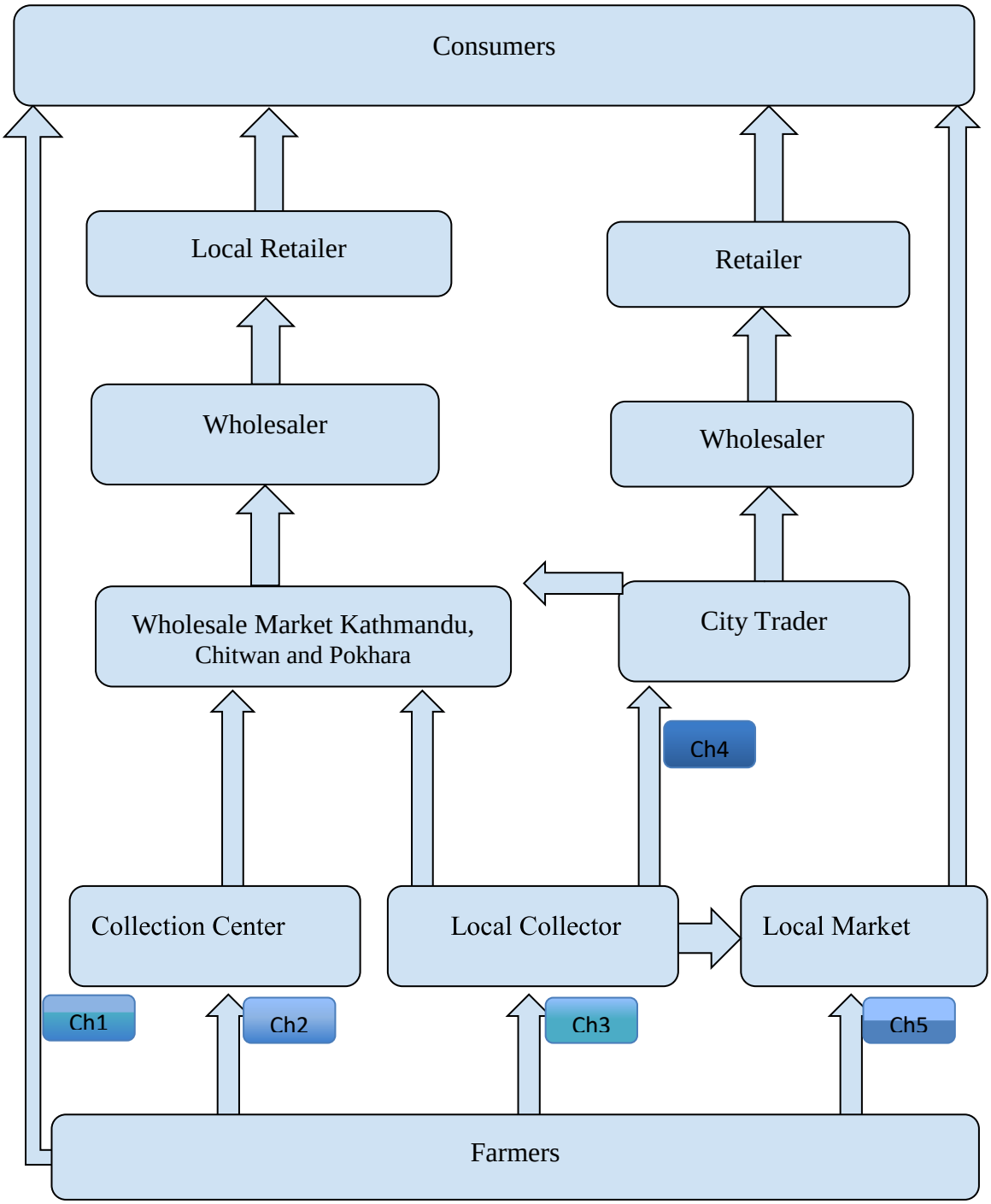
The development of rural road facilities in the district has facilitated farmers to use bicycles and motorcycles to transport the produce. However, the scattered household settlements due to geographical conditions in the study area are an obstacle for providing road services and public transportation. Therefore, the farmers transport the harvested produce by carrying it to reach the collection point and collection center. Generally, bamboo baskets (DOKO), plastic sacks are used for carrying the produce. The exposure of the harvested produce in the sun for a long time, and dusty road conditions result in quick deterioration and reduce shelf-life. Thus, the fruits and vegetables postharvest losses occur during transit (farm to market), due to poor road conditions, transportation methods, long market distance, poor transportation vehicles.

The estimated distance between the farm and the market varies from the study area. Generally, the respondents of the rural municipality (Galchi and Gajuri) supply their produce to Kalimati and Balkhu fruits and vegetable market that range from 50 to 60 kilometers (Km). Whereas, almost all respondents (farmers) said “they do not prefer to sale their produce in the local market by themselves because of extra labor, labor scarcity, and additional cost hence, they feel easy to sale to the collectors or collection center that save time and energy”. Benighat Rorang respondents mostly market their produce in other cities Chitwan and Pokhara because of the short travel distance in comparison to Kathmandu. The poor road condition of the developing countries not only increases the travel time but also increases travel cost and risk of the produce from being damaged or spoil. Higher the distance between the farm gate and the market, higher the chances of more marketing channels or value added (Adhikari and GC 2021).

5.5.1 Fruits and Vegetables Distribution Channel

The fruits and vegetable marketing channel is lengthy if the farmers' produce are transported in big cities like Kathmandu, Chitwan, and Pokhara. The farmers have less chances of direct contact with the wholesaler of the city market. The collector or trader bridge the gap between the farmers and the market. Therefore, when marketing or distribution channel increase the price of the produce and chances of loss also keep on increasing. An example derived from the one of the respondent farmer as well as collector in the study area explanation, at first he collect the farmers produce (Cauliflower) at rupees 10 per kilo and then he sold the produce to the market wholesaler in Kalimati market at least Rs.20 per kilo. The wholesaler again sold to the small wholesaler at Rs. 30 per kilo, and local retailer buys same cauliflower at Rs. 40 to 50 per kilo. Finally, the consumers have to pay Rs. 70 per kilo. The difference between the farm gate price and final consumer price is Rs.60 that includes the transportation cost and produces loss percentage. Hence, the increasing distribution leads to increase in price and percentage of postharvest loss.

Figure: 5.5.1. Vegetable Distribution channel



Source: Field Visit 2022

5.5.2 Marketing System of Fruits and Vegetables in Dhading

The farmers apply different marketing channels for sale of their harvested produce as shown in below figure. In Dhading, mostly the farmers preferred to sell their fruits and vegetables through the trader. The farmers contact the traders who are themselves farmers or village traders, and provide the possibility and appropriate day of harvesting of their produce. After the response of the collector the farmers harvest the produce, clean up and packaging done after general manual grading. During the field visit the farmers use plastic sacks, bags and cartoon boxes for less perishable vegetables. For leafy vegetables, the farmer uses traditional carrying medium DOKO made from bamboo, for tomato and orange plastic crates are in use. The packed agricultural produce is left at the side of the road for collection. The trader transported the produce to the wholesaler in big cities Kathmandu, Chitwan and Pokhara (Ch3). There is a presence of city traders in between local traders and wholesalers (Ch4). Then wholesalers sold the vegetables to the retailers of the market in Kalimati and Balkhu of Kathmandu or in Chitwan and Pokhara.

The market wholesaler sold the vegetables to the local retailers and vendors. Finally, consumers buy the product in the local market. Usually, the harvested produce has to pass 4 steps to reach the final consumers that increase and add price in each step. The collection center and small farmer cooperative also provide collection service and transport the vegetables to sell further. In the case of orange fruit, the farmers of Benighat Rairang rural municipality usually sell their produce to the local trader and local traders sell in the local market of Dhading and Chitwan and local vender of Prithivi highways. “The trader directly visits the orange farm and makes a contract to buy the whole garden at a wholesale price per tree. The price is determined on mutual consensus depending on the quality, quantity of oranges, and the market price. The farmers do not need to harvest and handle the produce. The traders are responsible for picking, collecting, grading, and packaging and transporting, and I am happy for transferring responsibilities and risks to the traders because the threats of getting fruits unsold and lost always worry the farmers. Last year, I lost almost 300 crates of oranges because I harvested late waiting for the trader to come but no one came, and I need to sell to a local collector” (Interviewee, orange farmer of Benighat Rairang). The orange farmers do not want to sell to the individual visitors directly at the farm gate even if he was able to gain a good margin. It could be the reason, either the orange farmer had already sold all the oranges or he did not want to break the supply chain. The case of vegetables was found different; the farmers sell their

produce at farm gate on consumer demand. More often, the neighbors and the local trader visit the vegetable farm with an intention to get fresh and quality vegetables at a reasonable price. Figure 3 shows the different marketing channels the farmers follow in Dhading. “The access to rural agricultural roads made it possible for trade from the farm but in the past, the farmers had to carry the harvested produce back using doko to sell in local highway shops” (key informant, local leader). The short market channel and direct presence of farmers’ cooperatives could benefit both farmers and the consumers. The interviewee farmers mostly expressed that “they sell their harvest to the middlemen who are usually from the same village and also a farmer himself who comes or sends vehicles to collect harvested produce. Therefore, they harvest the produce, pack it, and keep it at the side of the road for pickup. It is easy for them in one sense while in other ways they are compelled to accept the price provided by the intermediary in trust. Sometimes the farmers complain that their produce is rotten and spoiled, so the farmers have to accept less price for their produce, the vegetable price fluctuates everyday”.

5.5.3 Unstable Market Price -Wholesale price index, seasonable price variability

Price fluctuation in fruits and vegetable crops is common and comparatively high than in other crops due to seasonal price variability (Dahal 2010). Dahal further states the agricultural commodity price is relatively low just after the harvest and gradually increase up to the maximum before next harvest. As a consumer, I have also experienced on high changeability in price of perishable commodities because of high perishability in nature, festivals, seasonality, market shut down, strike, rise in petrol price that affect transportation cost, government strict rules and monitoring of fruit and vegetable wholesale market. During COVID-19 lockdown period when farmers could not sell their produce in the wholesale market then the farmers and traders apply door-to-door service to the customers at very low price because vegetable is highly perishable and the farmers cannot extend harvesting time, no cold storage to increase shelf-life of produce. Further, during the festival season the price of all fruits and vegetables is always at peak particularly the price of tomato, cauliflower, potato, onion, banana, apple and orange in the market. Regarding the price variation of the produce, the Rubina Bhujel (*pseudonym*) interviewee Farmer of Galchi expressed, “Vegetable farming is risky in spite of its high profitability ratio and the instability or fluctuating market price of the vegetables are discouraging vegetable farmers. When the market price decreases to a level is

less than the cost of production, the farmers have to bear a huge amount of losses and they are in pressure to sale their harvested produce either at a huge loss or have to leave at the farm for spoiling and rotting. Therefore, we farmers have only one option left, that is to accept loss, and if loss continues for the next three cycles of vegetable production then we cannot afford and have to lose everything". Rubina continues and says "It is very difficult for the farmers to receive reliable price of their produce because the trader tries to give less price to the farmers even though the price of their produce is selling at high price. The government is not seeing our problems".

There are various factors responsible for increasing the cost of production of the smallholder farmers' vegetables. That include, lack of access to information, extension services, high interest charged on informal source of credit, crop seeds varieties, lack of improved farming technology, high cost for inputs, poor rural road network, lack of access to inputs variables (labor, seed, fertilizer, pesticides) on time (Shrestha et al. 2022). On the other hand, the price decreases based on market demand and supply situation of the vegetables. Huge supply of vegetables than market demand is good for consumers as they expect to buy goods at a low price.

"The consumers are paying high prices even though the farmers are selling at low profit margins or even less than the cost of production. Sometimes we have to throw away our harvested produce when we are not able to get the harvesting labor cost and transportation charge. Further, the respondent farmers mentioned the traders are taking the benefit without investing a rupee" (Interviewee, farmer Galchi).

The farmers demand a 'Price policy' to fix the price to protect the farmers from loss and displacement (Bhattarai and GC 2020). The disconnection and gap between the farmers to the consumers and market result in poor market demand, price and the extent and causes of loss produce is known (Kumar and Underhill 2019, 15). Demand and supply analysis reveals that in the perfectly competitive market where buyers have a choice from whom they can buy the products, it is obvious that if the supply of any consumable goods increases then the price will decrease, and when the suppliers get good prices the supply increases (Shrestha et al. 2022). In Nepal, any interested person can enter into agricultural production and marketing having equal access to available resources, inputs and technology (Key informant, PMAMP, Dhading). As Nepal does not have, a direct state controlled market, and a price support policy for fruits and vegetables, the farmers are always at risk and vulnerable (Bhattarai and GC 2020). The

minimum support price (MSP) is a government guaranteed fixed price for the produce that was introduced and implemented in the seventh periodic plan (1985-1990) for paddy and wheat but could not succeed, and was removed in the fiscal year 1997/98 (Kaini 2020). MSP fix after produce harvest, the lengthy bureaucracy procedures, involvement of many institutions and poor coordination are the factors for failure of MSP that leads to displacement of the farmers (Bhattarai and GC 2020).

5.5.4 Minimum Support Price (MSP)

Bhattarai and GC (2020) claim that the price policy implemented during 1957-1981 was not successful due to lack of coordination, poor infrastructure, poor distribution system, and proper guidance however, it is important to implement at least buy back guarantee in case of vegetables and potatoes even though fixed price mechanism is not possible because of it perishability nature. The winter season is good for seasonal vegetable production and harvesting so usually the supply is more in this time. The Asian Development Bank (ADB 2019) report mentions that even though the climate is suitable for the production and harvesting of seasonal vegetables, the huge amount of fresh vegetables imports from India and China influences the vegetables price and market for the Nepalese vegetables. The postharvest loss specialists (key informant) express “Even import of few tons of vegetables from the India influence the Nepalese market because Nepal vegetable market is not fully under government control, the subsidized Indian vegetables are cheap so despite of government effort to minimize its influence, the trader are playing the role in decreasing the price of Nepalese farmers vegetables.” This statement underlines the situation of vegetable market and influencing party for price increment.

Policy intervention to improve seed variety, loss in transportation, high transportation cost due to market distance and frequent rise in petrol price, and many steps of informal marketing channels are the other reasons for less profit for the farmers (key informant, farmers commission). The current market situation of fruits and vegetables, it is assumed that the consumers are paying three times more for the produce than the farmers are receiving from the sale syndicate among marketers to arrange markets, and due to high cost of production (Khatiwada 2020), intermediary influence in fruit and vegetables value chain (CASA 2020).

The majority of the interviewee, farmers expressed “During vegetable season, our produce is devalued; the selling price we received from the collector is less than our cost of production, because we have no option rather to sell on their price. This is because the government does not fix the price of our vegetable produce. We have to pay our debt to the bank, finance or cooperative where we have taken a loan. If we do not sell at the trader price then either we have to leave the produce at the farm to rot and use as manure or use as livestock fodder. So, we sell at a loss”. In response to MSP for perishable produce and to save farmers from loss, the agriculture officer (Key informant) states “the vegetables grown in almost every part of Nepal where cost of production varies on the same commodity and due to perishable nature it is difficult to put minimum support price”.

A young interviewee farmer of Galchi Rural municipality who is directly involved in transporting and selling vegetables to the wholesaler in Kalimati fruits and vegetable market, Kathmandu express, “the market fixed the wholesale and retail price of the fruits and vegetables and published them on the website and displayed them on the market screen but the village farmers who do not know how to access information are being compelled to sell at the trader price that is mostly low”. Market information is found significant for the farmers in crop selection, growing season, harvesting time and marketing.

5.5.5 Trading and Pricing Method

The farmers transport produce in plastic sacks or polythene bags to the collectors putting the sender and receiver name, vegetable types, quantity, and mobile number. Later on the farmers and receiver communicate on phone about the total price of the produce and entry in a simple copy. The farmers communicate with other farmers about the per kilo price fix for his similar produce. If the farmers found a similar price on the same produce then they agreed with the selling price given by the collector or intermediary. The collector and farmers of the same village are good for the farmers because the farmers believe their own villagers will not cheat them so they prefer to sell him. Sometimes the collector only collects and handovers to the wholesaler at that time the farmers communicate to the wholesaler directly. Therefore, the selling price differs between the same produce of different farmers. Moreover, the trading price is based on farmers' produce quality, quantity and market demand. On top of this, the trading is based on mutual trust, and understanding (social capital) between the farmers and the receivers.

5.5.6 Discussion

This section focused on identifying different types of postharvest loss and the factors behind the fruit and vegetable loss and the farmers' perception about postharvest loss and its causes. The study respondents' responses about the reasons of produce loss on the farm and during the transportation are discussed. The key informants' insights are additional backup for knowing the postharvest loss occurrence and reasons. According to the interviews with the farmers and the key informants; numerous factors are identifies and discussed. The farmers' knowledge and practice on postharvest handling and management, storage facilities, climate change, labor shortage, market structure, lengthy value chain, fluctuating and intermediary and trader price influence, and government policy on minimum support price on perishable produce are recognized and responsible for postharvest loss in fruits and vegetable farming. Some of the postharvest loss causes are manageable through applying postharvest technique and tools. Most of the factors are manageable through the cooperation and coordination from all value chain actors including farmers, trader and from the government efforts. Human behavior related careless handling from the hired labor and transporter damage the produce that is manageable from awareness raising and training. For the fulfillment of labor shortage in the agricultural sector less labor-intensive farming and introduction of climate resilience modern technology is viable. Likewise, restructuring local market (Haat Bazar) in every local level is beneficial for the farmers in shortening the value chain that result fair price of the produce. On the other hand, the perishable do not need to transport all the way hundreds of kilometer in non-refrigerated vehicles in hot weather that save produce from being lost. In order to tackle the problems of postharvest loss, the farmers' activities before and after harvest are presented in chapter 6.

Chapter 6: Farmers Strategies for Postharvest loss

6.1 Introduction

The chapter six includes the factors of postharvest loss notified and recorded during the field visit. The farmers' strategies for reduction of the postharvest loss through their farming techniques and preservation methods are presented. Factors affecting post-harvest losses vary from place to place depending on the season, crop varieties, infrastructure, postharvest handling and management practices, temperature, climate change, market structure, and the government policy. Food loss reduction is for food safety and food security all the time. The farmers are the producer who holds the responsibility to produce and supply safe food to the consumers. Thus, farmers' role is significant in the food value chain from pre-production to pre-harvest, harvest and postharvest. With reference to literature reviews, field visit data and information, numerous driving factors of postharvest loss are identified and categories in table 6. This research aims to identify the causes and explore the farmers strategies in postharvest loss minimization, following reasons and roles are pointed and discussed.

Table: 6.1 Causes of postharvest loss of Fruit and vegetable and farmers' role in Reduction

Causes/ driving factors	Role/Action
Postharvest handling and management	Training/ IK use in PHH and management Organic vegetable Production Use of bio-chemical example neem (*Azadirachta indica*), asuro (*Justicia adhatoda)*, titeypati (*Artemisia vulgaris L)* Food Storage (Food fermentation, drying), off-season vegetable production to reduce oversupply of seasonal produce.
Agricultural labor shortage	Crop diversification (crop substitution), adopt low labor intensive farming system and crop selection
Market Structure	Crop substitution, crop diversification, access to local market (Haat bazar), market information,

	Market (off-season vegetable/ local seed use reduce cost price of the produce/ reduce market channel.
Climate change	Climate resistance crop, tunnel farming, climate smart agriculture and crops, /local seed use
	Government Role
	Policy, strategy, Program and project Strengthen local market (haat bazar) stabilize market

6.1 Crop Diversification

Crop diversification is the traditional approach based on low input extensive and agricultural practices that could be an effective approach to save food from being lost and improve soil fertility (Dahal 2010). Barman et al (2022) claim "Crop diversification is a sustainable agriculture development approach and a significant technique for efficient land use, to increase crop production through improving the soil qualities". The respondent farmers seem enthusiastic in shifting previously cultivated low yield and low value to high yield and high value crops to gain more income. According to key informant, AKC, "the crop diversifications need pre-cultivation plan and market before selection of crops for getting quality and quantity of produce". For example; one of the respondent farmer explain, last year he produced high amount of cabbage but he could not sell in the market due to low price and bear high amount of economic loss and postharvest loss. So, this year he is thinking to cultivate beans instead of cabbage with a hope to get good return. This is need-based crop diversification described in Barman et al. (2022). Trend of crop diversification found in study area; cereal crops (maize)-vegetables (seasonal) - off-seasonal vegetables- oil crops.

6.1.1 Crop substitution

Crop substitution is a replacement of any crop that is continuously grown in the farm as monoculture crop (Barman et al. 2022). The farmers' crop substitution activity is beneficial in terms of profit gain and soil fertility (Key informant, AKC, Dhading). In the study area, the

farmers have been found involved in vegetable farming and substitute cereals crops. “I replaced maize crops that have been continuously growing for years for vegetable and oil seed production. The cereal crops market value was less and it takes 3 months (local seed) for harvest. I have to wait long to earn from cereal crops than from the vegetables. Now, hybrid maize seed is also available but not suitable to produce maize flour because taste is not good like local maize (Interviewee, Gajuri). “The process of substitution of one or more agricultural products for another is defined as crop diversification and it is demand driven, based on need, situation specific, and popular in developing countries, Barman et al. (2022). Another interviewee farmer had cultivated mustard plant for selling green leaves and pure edible oil for self-consumption, as well as to earn decent income from the surplus produce. The farmer opined that “many farmers get involved in seasonal vegetable production that result in overproduction of the same vegetable and farmers receive less price due to competition so, this year I cultivated mustard seed for oil in some part of land. The price of oil has doubled in the market for refined oil and no need for continuous labor and care like vegetables”. The tendency of farming changed as farmers are shifting from one crop to another for higher net returns, save food and to get rid of labor shortage.

The farmer’s strategy for crop substitution is found effective for getting good profit margin as well as in food loss reduction. The young interviewee farmers are not found well educated, experienced, and aware in terms of scientific advantages on crop diversification rather his selection for alternate crops was based on market demand and profitability. Crop substitution and crop intensification are benefits in terms of profit, secure market stability, provide opportunity to produce market demand crops, balance price fluctuation effects, maintain healthy soil, reduce labor shortage problem (Barman et al.2022). The research finding of Dahal (2010) reveals crop production diversification is shifting from need-based crops to market demand vegetables and other crops that has improved socio-economic status of about 90 percent respondents. In Nepal, crop intensity is high, the farmers’ traditional method and preference of multiple cropping and multiple cultivating times in the same farmland is persistent (Takeshima and Bhattarai 2019).

6.2 Off- seasons Vegetable Production-Market, Climate Change

Vegetables are a high-value crop (HVC) as they provide higher income per unit from the available resources. “Vegetable farming provides three times or more income than from the

cultivation of traditional cereal crops farming therefore farmers' attraction is natural" (Key informant, NARC). The data show the production area and the vegetable production both are in increasing trend in Dhading (MoALD 2022) that reveals farmers' attraction to vegetables is increasing. One of the respondents of Gajuri explained, "We (farmers) gradually shift to vegetable production with demand for fresh produce increasing in Kathmandu and other major cities because of higher income gain. The number of vegetable cultivators increases doubled within 5 years resulting more seasonable vegetables production. The year round vegetable demand and good price in off season vegetables encourage the villagers". The HVC is appropriate and beneficial to smallholder as well as marginalized farmers' vegetable farming because it can be started with little investment and able to get quick return (GC and Hall 2020). "Last year I earned 5 lakh from 8 ropani land (0.4 ha) producing both seasonal and off seasonal vegetables. In the season when most of the farmers produce the same types of seasonal vegetable, I cultivated potato and rapeseed during December to February" (Interviewee, Galchi).The vegetables prices usually decrease during December to February (Kalimati vegetable price trend). Consciousness on market demand and off-season vegetable production benefit farmers from receiving extra income gain, in other part farmers do not need to throw vegetables due to decreased price from excess production and over supply. Crop diversification seems beneficial and contributes to postharvest loss reduction.

Interviewee, farmer of Galchi claims "the local crop production is subsistence, chemical pesticide free and traditional farming because I use animal manure and bio-chemical for vegetable production". With the revolution of agricultural sector commercialization for economic growth and uplifting rural farmer livelihood, the farmers used to change in the agriculture farming system (Key informant AKC). The government defines commercialization of agriculture as "the process of transforming subsistence production to production for sale of surplus products and services" (ADS 2015-2035). Rapid population growth and increasing urbanization in Nepal has put increasing demands on agricultural production (See GC and Hall 2020). Then, hybrid crops started to reach the farmers' field during the 1990s (Pandey and Shakya 2016).

6.3 Hybrid Vs Local Seeds

The historical vegetable development in Nepal overview from Pandey and Shakya (2016) mention the use of hybrid was popular only after 1980 in Nepal. Most of the interviewed

farmers used both local seed and hybrid seeds. “More than 50 percent hybrid vegetables are growing in the farm for high production, and easy availability in the village shop and agro vet” (Interviewee, Galchi). The other respondent expressed, “For high production I use hybrid seed but I found the cost of production is high in comparison to local seed as it needs more care and chemical fertilizers. Use of more fertilizer, the soil of my land is no longer fertile, so I decided to use local seed even if the yield is lower”. The government agriculture commercialization policy for economic growth introduced hybrid seeds throughout the country during the 1990s (Key informant, Farmers commission). Hybrid seeds have 30% higher yield than local varieties Hybrid seed requires many nutrients than open-pollinated ones (Shrestha et al. 2022 and Augustin 2022). Therefore, the farmers have to use many chemical fertilizers that accelerate the depletion of soil quality and the shelf life of the produce. The cost of production of hybrid crops is more due to more need and use of chemical fertilizers, pesticides, frequent observation and care demand additional labor (Shrestha et al. 2022). The labor shortage both skilled and unskilled is another constraint for agricultural sector enhancement in Nepal. The negative impacts of using hybrid seed encourage farmers to use local seeds, and the government is promoting local seed varieties to increase organic farming and to protect soil from further damage (key informant, PMAMP). Nepal is slowly starting to return to organic farming and slow down use of hybrid seed is good news (Augustin 2022). There is a wide range of technologies available that, if adopted, would enable smallholders and larger producers to improve the quality and quantity of food/grains during postharvest handling and storage. The PHL strategy should be better integrated into agricultural programs to provide technical advice and affordable solutions to farmers (Augustin 2022). Many respondents expressed, the local crops produces do not spoil quickly after the harvest due to less chemical used during cultivation. For the hybrid crops more fertilizers and pesticides have to use to produce more that decrease the shelf-life of the produce and causes high amount of postharvest losses.

6.4 Use of Traditional Bio-chemical

Dhading ranks third on the list of the highest pesticide using districts (MoALD 2022) that result in soil infertile. “While adopting commercial vegetable farming the farmers use excessive amounts of toxic pesticides to increase yield and maximize profits thus, PMAMP is continuously implementing an awareness and training program on using organic fertilizer, taught to make and use biological pesticides ” (Key informant, PMAMP, Dhading). “The

government and nonprofit organization's initiative and awareness raising program on using less pesticides in the district made farmers use biochemicals in the vegetables that have been practiced from generation" (Interviewee, Gajuri). The biochemical (neem leaves, aasuro, baanmara, straw) are bio-products and traditional method applied for packing produce for transporting rather than using chemical for ripening and maintaining green for vegetables (Interviewee farmer).The paddy husks, litchi and mango leaves works as isolator that save produce from physical damage Value Chain Development of Fruits and Vegetables Khatiwada (2020). "The natural biochemical and livestock manure are good for plants and make soil fertile. The produce is tasty and healthy, do not spoil and rot quickly" (Interviewee, farmer, Galchi). The Farmers realized they had used more chemical fertilizers and destroyed the land and soil with a greed of more production, and costly for them. "Now farmers have realized the advantage of our livestock manure and freely available bio-plant chemicals. For example bojho (Acorus calamus) extract for management of storage insect pest. Indigenous farming method is non-harmful therefore the produce does not rot and spoil faster than chemically treated produce" (Interviewee, Gajuri). During the field visit, the heaped of livestock manure covered the whole farm and the farmers' expressed opinion during the interviewee symbolized awareness and willingness in returning to chemical free farming. The farmers' role is important in every process of farming from pre-harvest to postharvest until they transport and sell their produce. The agricultural practices perform by smallholder and subsistence farmers in low income countries for climate change mitigation and adaptation strategies like changing crops varieties, fertilizers inputs and soil management practices, incorporating new technologies, income source diversification, and management strategies on farming patterns enables to address the impact of climate change on food loss (Sikha et al.2020). FAO (2017) mentioned climate smart technology and improved interventions such as land use practices, storage, processing, cooling, packaging and distribution support to cope up with climate change and reduce post-harvest loss.

Farmers of the study area are found responding to the climate change through multiple cropping, companion planting, crop rotation, animal husbandry, manure system. One of the farmer expressed his opinion, "Learning from experience, I think our own farming system and cropping pattern is good to grow healthy crops. Before, we cultivated local seeds and produced different varieties of crops in the same land. Our livestock manure was enough for fertilizer but due to increase in use of hybrid seeds, we need more chemical fertilizers but that are

expensive, and difficult to get on time. I experienced that inorganic fertilizer used crops quickly spoil and rotten in comparison to local crop and organic use fertilizer. Other thing, if we grow only one crop and if it does not grow well then we will be in loss, what we eat, and sale, we have to buy from the market at high cost and they are not in good quality therefore I always cultivate multiple crops even though the production quantity is less, it saves from excess production and more loss occurrence if I could not sale at the reasonable price in the market". This show farmers concern towards the produce loss and potential economic loss.

The agriculture sector is highly vulnerable to climate change in comparison to other economic sectors. The diversified cropping systems have great potential to minimize the market risks, providing diverse and nutritious food at the household level, and impact of climate change. The risk management and produce loss reduction strategy of the interviewees' farmers have saved crops that contribute to GHGs emission, and climate change. Although a rise in temperature could have some location-specific positive effects, Nepal is much more vulnerable to the impacts of climate change mainly because of variability in weather conditions related to rising temperature and changing rainfall pattern, including drought (Thapa et al.2029).

The interviewee farmers' response indicates they are experiencing the impact of climate change on their farming system and have affected agricultural produce from 4-5 years. Due to the delay in monsoon, less rainfall, unexpected extreme weather and rain the farmers are changing cropping patterns. One of the respondents stated, "due to delay in winter rain and late monsoon, the farmers are not able to plant the germinated cucumber, squash, pumpkin and other vegetables as before during (February-April). The unexpected rain and hailstorm destroyed the flowers of the fruit tree (mango and litchi) and damaged vegetables extremely". The other respondents are confused about the use of organic and inorganic fertilizer, advantages and disadvantages of modern farming systems and which one to adopt due to access to proper information. The Key informant from AKC mentioned, Dhading farmers plant more hybrid crops and extreme use of inorganic fertilizers to increase production. The national statistics information report (MoALD 2022) revealed Dhading ranked in third position in use of inorganic fertilizers among all districts. Dhading has made some progress to drop down one position in 2022 that show positive result and farmers' consciousness towards chemical fertilizers impacts on land, soil and agricultural produce. Most of the interviewee farmers agreed they are using both organic and inorganic fertilizers because they have planted both local and hybrid crops, and expressed the hybrid crops need more chemical fertilizer for quality

and quantity production that has increased their cost of production and in return the soil has lost its quality and dryness increases.

In brief the farmers' preference and current practiced while crops selection, cropping pattern and way of farming are significant strategies to cope climate change, market demand and supply, and postharvest loss reduction. Though these farmers' strategies are seen as pre-harvest activities however, it could be effective in minimizing postharvest produce loss and discussed in this chapter. Correspondingly, smallholder farmers' activities in harvest handling and management of fruit and vegetable are another challenge until the produce are sold in the market. In addition, farmers' contribution in handling unsold produce through traditional technique for saving food is discussed below.

6.5 Traditional Method of Vegetable based fermentation

The vegetable-based fermentation is postharvest farmers' strategies to save unsold harvest produce. Fermentation is the oldest and traditional method of surplus vegetable preservation skills passed from generation to generation as a part of culture (Asoga et al.2017). Traditional fermentation helps to prevent food losses and extends shelf life of the harvested produce (FAO 2013). It also helps with value addition, capitalizing, increase seasonable food availability and nutrition to the people (Shrestha et al.2012). It benefit both producers and consumers due to nutritional value and microbiologically safe (Khadka et al.2020). Traditional fermentation of food is processed at the household level for home consumption using locally available raw materials. Most fermented foods are acidic and some are alcoholic (Krishnan et al.2014).

In response to the question about the harvested surplus agricultural produce management, Laxmi, one of the oldest interviewee of this research opined that "fruits and vegetable fermentation was started to save and store surplus vegetables for the future and has become a culture to prepare traditional food. In the past, the farmers produced only seasonal vegetables following the cropping calendar, and during the rainy season the production of vegetables is difficult in open areas so, for leafy vegetable availability the female member used to prepare fermented food as an alternative. There are many types of fermented food in different cultures; *Gundruk, sinki, khalpi, taama,* and *masaura* are the popular ones (Khadka and Lama 2020). People need skills and technique to make good quality products because if the moisture remains

in the products then it will spoil and not suitable for human consumption but good ones can be stored for years. Now, these fermented products are sellable in the city market and exported, target consumers are Nepalese living abroad getting good market price."

Through production of fermented traditional foods *gundruk* and *masaura*, Laxmi is earning good income, and also contributes from getting harvest vegetables lost. The study of (Asogwa et al. 2017) documented varieties of low-cost fermentation products of Africa and claim they have been practiced from thousand years as a part of *African* traditional culture, suitable for small scale industries but undervalued. The traditional fermented foods have become marketable commodities. For example; bamboo shot (taama) is available as canned food in the supermarket. "The Chinese have been learning to make 'Gundruk' and exporting large quantities in Nepal for the last 5 years. Nepalese farmers have to make marketable products, have to use skills that they already earn and contribute in saving food (key informant Kalimati vegetable market officer). *Gundruk* is indigenous veggie food product (Shrestha et al. 2012), prepared by the lactic acid fermentation process of leafy vegetables and popular among the Nepalese over Nepal, and northeastern states of India (Khadka and Lama 2020). *Gundruk* is prepared from the different types of vegetables leaves such as; board mustard leaves (rayo saag), mustard, cauliflower, cabbage, and radish leaves. Gundruk preparation is suitable in less humid weather during December to February (Khadka and Lama 2020) but one has to be aware about the sunny days for getting a good quality product. The quality of Gundruk is determined from the color and taste (Shrestha et al. 2012). Suitable weather prevents Gundruk from fungus decaying and from getting the best product.

6.5.1 Gundruk Preparation Process

The preparation method is different depending upon the region and tradition however; the common method explained from the interviewees is presented as follows. First the leaves are left to dry under the direct sunlight for 2-3 days. The withered leaves are cleaned up with water before drying; this process is called blanching which helps to minimize nutrient loss (Masarirambi et al.2010). After that, whole leaves are put inside the jar and pressed with hand as much as possible to take out surplus water. The mud or plastic jar can be used but traditional earthen jar is more suitable to get a good taste. After that, dried banana leaves or special tree leaves (sal tree leaves) are used to cover the materials. Clean heavy stones are put inside the

jar for compressing the materials and left outside in direct sunlight for 15 to 22 days for the fermentation process. When the fermentation odor develops within 22 days, the material is taken out for sun drying. The raw *Gundruk* can be consumed by making pickles. After 4-5 days of sun drying, G*undruk* is ready for storage in a dried form, and could be preserved for 2-3 years. *Gundruk* can be consumed as soup, pickle and curry that depend upon the making process and other additional ingredients. Further, for detailed *Gundruk* preparation process with temperature calculation (see Shrestha et al. 2012, 318). *Gundruk* is similar to popular Korean food 'Kimchi' but differs in taste and making process. The nutritionist referred '*Gundruk*' as a nutritious food, as it contains lactic acid, vitamins, minerals, and therapeutically active compounds (Shrestha et al. 2012).

Similarly, the farmers seem to be interested in making another product '*Sinki*' from the vegetables prepared as *'gundruk*' making process. *Sinki* is fermented from the root section of radish, while *gundruk* is made from the leafy vegetables. It is popular in Nepal, Darjeeling, Sikkim and in Bhutan. For the fermentation process, *sinki* takes a longer time, about 30 to 40 days. The shelf life of *sinki* is similar to *gundruk* that is 2-3 years depending upon the quality of the product (Khadka and Lama 2020). The study respondents usually make sinki for household consumption and to give gifts to friends and relatives.

Another product called 'Masaura or Masyaura' a fermented sun-dried vegetable ball, is a traditional product popular in Nepal in the hilly and terai region of Nepal. The '*Masaura*' making process is simple and prepared from a mixture of black gram, taro stem, yam, green garlic, and bottle gourd. It is traditional food usually prepared in hilly regions but it is popular among other people in Nepal (Khadka et al. 2020). The respondents of Galchi and Gajuri used to prepare '*masaura'* every year from the taro and black gram and store it for year round consumption. Taro is a high yield crop of Dhading (see table 2) that does not require frequent care like other vegetables.

6.5.2 Masaura Preparation Process

The black lintel is shocked all night and needs to remove the cover through washing with clean water then; the paste is prepared through grinding. The vegetables taro stem and yam are mined and mixed in a certain portion in a lintil paste. The mixture is prepared as a ball and sun-dried

for 5-6 days and *masaura* is ready. This traditional food preservation technique is unique and practiced in the hilly region of Nepal.

6.5.3 Pickling

Pickling is another method of vegetable preservation popular in many parts of the world. Krishnan et al. (2014, 10) claim 'Pickling is a preservation technique discovered and practiced from our ancestors in which vinegar and other acid is used for preservation.' The word Pickle is called *'aachar'* in Nepali and Hindi language. In eastern part of Nepal the word *'Khalpi'* is used for cucumber fermented pickle (Khadka and Lama 2020), while, in other parts of Nepal it is popular through the name of the product use for example; Cucumber Pickle, Lime Pickle, Mango Pickle, Indian gooseberry Pickle, Mixed pickle and many more. Mostly the traditional natural preservatives are used as ingredients for pickling in Nepal are sugar, salt, turmeric powder, mustard oil, and rapeseed powder, green chili whole, Sichuan pepper, red chili powder (Khadka and Lama 2020). Mostly, locally available and affordable materials and equipment are used by the local people for the fermentation process (Krishnan et al. (2014).

The Pickle making process and ingredients are different and depend upon the folk tradition and availability of the materials. In the study area, pickling is observed in every household. Almost all respondents state, "the surplus harvested produce is utilized in making pickles for own consumption. In every household female members prepare pickles during the available season, pickle making is an art and a good appetizer which is consume daily with our daily main food (rice curry and lentils) but we also eat pickle with snacks." The pickles from radish, lime, mango and Indian gooseberry (amla) are mostly consumed and popular in the study area. It could be the reason for easy availability of these produces during the season and utilization of unmarketable produce that are going to lost. The local organization is also providing pickle training for female members to generate income through selling in the city market.

Fermentation is indigenous knowledge acquired by observation and needs skills and experience for good. Further Khadka and Lama (2020) claim fermented foods provide various nutrients that are not available in other natural foods and useful during the food unavailability time. The traditional fermented product is "a part of culture" that could minimize high postharvest perishable losses (Asogwa et al.2017). Fermentation is indigenous food preservation method (Asogwa et al.2017) that is socially and culturally accepted food, and consumed from ancient

times (Khadka and Lama 2020), and supports food loss minimization and for food shortage time (Khadka et al.2020).

6.5.4 Drying Method

Drying is another technique for food preservation. The sun drying is traditional and sustainable method of drying fruits and vegetables in developing countries (Masariambi et al. 2010: Faqueezada et al. 2018). All respondents are practicing sun drying fruits and vegetables from generation for future household consumption. The fruits and vegetables are chop into regular small thin pieces and put outside for 5-6 days for sun drying depending upon the products. In fruits type, the locally available mango and Indian gooseberry (Amla), are dried and stored for making fresh pickles, whereas vegetables like; mushroom, bitter gourd, tomato, cauliflower and mustard leaves are sun-dried and stored in airtight containers.

Sarala (*pseudonym*), a respondent of Gajuri told, "In the past we were not aware of the drying process; rather we practiced just for picking and making *gundruk* and *masaura* from surplus produce. Through friends, relatives, and social media (*facebook, tiktok and youtube*) I learnt many fruits and vegetables other than mango and amla (indian gooseberry) can be dried and store. For example; I learnt to make candy from papaya, apricot, Nepali hog plum (lapsi/*chaerospondias axillaris*) and I am thinking of taking training from food department and technology Nepal in future for establishing small business". Technology and access to mobile phones and the internet seem to have great influence even in small rural municipalities. Dehydrated food eliminates the risk of loss, saves money, has a long shelf-life, and maintains nutrients compared to other food preservation methods (Khadka and Lama 2020).

6.5.6 Zero Energy Storage, Postharvest Handling and Management Mitigate Climate Change

Storage is important to extend the shelf life of fruits and vegetables by controlling the rate of respiration, transpiration, ripening and undesirable biochemical changes and disease infection (Khan et al.2017). Storage increases food availability and reduces malnutrition (KC et al. 2016). People practiced a number of indigenous techniques for the management, storage and

use of bio resources. Zero energy storage technique is a sustainable method (Bhat and Khan 2017) and found in hilly regions in Nepal for apple and citrus storage (Bhattarai 2018).

Nabin Basnet (*pseudonym*) respondents reported, "We have little produce for self-consumption, mostly cereals (Paddy, maize) potato, lintils and dried beans so we store them at home. The vegetables are harvested, graded, sorted, packed and sent to the collection point or to the collection center on the same day and remaining we spread on the straw mat '*sukul*' or bamboo mat '*manro*' on the floor". Dol Bahadur (*pseudonym*) respondent said, "Sometimes due to unpredicted rainfall, the farmers have to do quick harvest the produce to save from being lost, and modern storage rooms are not affordable, from generation to generation we use the dark room of the house for surplus vegetable storage".

Laxmi Bhujel (*pseudonym*) from Galchi rural municipality 3 said, "Previously we had a mud house which is good for storage of harvested produce (crops, vegetables and fruits), In 2015, the earthquake damaged my house and I built a concrete house made from cement and bricks which is common and for status purpose. I have experienced that mud house was good enough for preservation because the produce did not used to spoil and rot quickly in the past in my storage room. I think that in summer mud houses help to lower the temperature whereas in winter it keeps warm. Now, the cemented floor is not good for storage, as the harvested produce could not keep for a long time and easily rotten. So, I have built a small traditional storage house made from mud, bamboo, slate, wood to store extra produce before sending it to the market.

The environmentalists view, traditional mud house is made from natural materials and more earthquake residence than cement house. The mud walls serve as natural insulation that reduces the energy needed for air conditioning and heating which are the sources of greenhouse gas emission. The comeback or revival traditional mud house helps mitigate climate change effects, or address climate change challenges.

Traditional storage made from mud is cost effective, ecofriendly, and provides high self-life of the stored agricultural products (Mobalade et al. 2019). The natural features of mud houses provide natural insulation thermal comfort and maintain a comfortable indoor temperature inside the house (Neupane et al.2014). Therefore, strategy applied from Laxmi through building mud house storage is scientific and impressive in the term of postharvest loss reduction.

Another respondent shares “I bought refrigerator last year from the money sent from my son who works in abroad. Actually, I do not want to buy but my son insists me again and again and said it is good to keep excess food, vegetables, water and others and it will not spoil quickly. Yes my son was right but I do not like the taste of the water from the freeze and we do not have habit to eat leftover food. We cook every meal every day and give leftover to our livestock. We harvest seasonable vegetables when we need from our nearby kitchen garden, we like to eat fresh vegetable. With great laugh he said it is useless for us now so when he returns he will use it”.

This is culture and tradition of most of the rural villagers that they do not eat leftovers rather they like fresh harvest vegetables to cook as much as they need. This indicates there is less chances of food waste.

During the field visit the storage for storing farm produce after harvest is located far from the farmers’ farm land, and commercial farmers, businesspeople and mediators often use cold storage for storing potatoes and onion for business purposes. One of the respondent express “the cold storage is far from my farm and I do not have vehicle to transport and I heard if the temperature is not right then all the produce will rotten and spoil”. Key informant, Agriculture Knowledge Center shares “The local government has built ‘Cool Bot’ storage in Nilkhantha municipality of Dhading that is operate by the cooperative run collection center, and there are plans to establish in other municipalities in future for easy access to many farmers”.

6.6 Discussion

This section endeavor to analyze and summarize the main findings on farmers’ different strategies practiced during initial farming phase to pre-harvest and postharvest of the produce which are assumed effective for minimizing postharvest loss of fruits and vegetable. The farmers’ pre-harvest activities significantly impact on the produce quality, quantity and loss percentage of fruits and vegetable. Throughout this research, the respondent farmers’ perspective and experience on selection of horticulture farming (fruits and Vegetable) through substitution of less profitable traditional cereal crop farming are incorporated and discussed. Through the historical overview of Nepalese agriculture development in the hills, cereal crops (paddy, maize, and wheat), pulses and oilseed crops were major crops cultivated. However, through the influence of government policy and strategies on commercialization of agriculture,

horticulture development, vegetable farming got priority. The ministry of agriculture report reveals the increasing rate of growth of vegetable production area, production and productivity in Nepal that reflect vegetable farming is getting prioritize since 1980s onwards. Various facts behind the farmers' preference of vegetable farming is discussed in previous section 6.1. Nevertheless, small investment, high profitability and quick turnover ratio are among the reasons behind increasing vegetable farming in Nepal. Most of the respondent farmers agreed on changing crops from cereal crops to vegetable crops in the study area. The tendency of shifting from traditionally grown crops to more market driven crops is crop diversification. Barman et al. (2022) consider crop diversification as cost-effective, environment friendly and reasonable approach for reduction in agriculture uncertainty from climate change.

The study area some respondent farmers mention the income gain from the vegetable is triple times more than from cereal crop cultivation when they are able to get good quality produce and appropriate market price. Meanwhile, the case is different for some farmers because they quite often sell the produce for a price less than the cost of production due to oversupply of seasonable vegetables in the market. Some lack labor shortage in produce harvesting and transporting time. Such situation demoralized farmers in vegetable farming and they consequently have undertaken crop diversification and multiple cropping for economic reasons, and for produce loss reduction. For example; one of the respondent farmer has started oil crop (mustard) cultivation rather than focusing on vegetable farming as before. The almost all respondent farmers are practicing mixed crop farming for self-consumption and loss minimization. The other benefits of crop substitution is to get market for the produce because limited produce supply result high price and decrease over production. Likewise, from the respondent experiences, and key informant agriculture officer, use of bio-fertilizer and livestock manure are effective for restoring and increasing soil potency and productivity, and for protecting produce from quick spoilage. The subsistence farmers are experienced and familiar with the cropping system beneficial to the soil, produce and to the farmers in terms of quality and quantity food production and for the soil productiveness. Further, some respondent farmers thought the use of local seed crops is better than hybrid crops because local crops possess capacity to cope the environment and easily grown, however some respondent claim hybrid crops is better for more production and productivity. Therefore, a separate study on local crops Vs hybrid crops for farmers benefits and for sustainable development is essential. Shrestha et al. (2022) claim that cost of production of hybrid crops is usually more than local crops due to essential of more pesticides, insecticides and fertilizer. Therefore, when the

farmers are not able to receive good price of their produce then it will be economic loss. Some respondent complain that they are not able to get market for their produce and have to sell either in low price than cost of production or have to throw the vegetables in the farm for manure. In such case, the farmers either have to limit the production or have to receive support from the government to access to market for selling at appropriate cost. The farmers strategy to cultivate local crop for less and quality production is seems appropriate for postharvest loss minimization. While some respondent use traditional and indigenous knowledge such as fermentation, smoking, drying and pickling for saving the surplus produce and the excess that could not sell in the market.

There is great possibilities of postharvest loss reduction of vegetables through food preservation method for example canning, jam making, sauce or ketchup, tomato puree, paste, crushed, freezing fruits and vegetables, drying and pickling. The indigenous knowledge of fruits and vegetable preservation techniques that include vegetable fermentation, pickling, drying has been practicing since century for food availability purpose in off-season. Currently, these traditional techniques are commercialized and industrialize at national level and international level in different brands. The global market of canned food is increasing rapidly moreover, high percentage of people out-migration from one county to another could be another reason for increasing demand that could fulfill the desire of missing home country food in abroad. Migrants of particular country living in abroad like their own traditional food, this food fermentation process and availability in abroad fulfill the missing of home country food. Traditional food preservation does not require additional preservatives apart from natural preservatives that are being used, therefore there are no side effects from its consumption How the traditional food industrialized and globalized is interesting part that need separate study. However, through applying this traditional technique, there is possibility for the farmers of becoming agribusiness entrepreneur and save harvested produce from being loss that were unable to get market and good price for selling. The role of government is essential for entrepreneurship promotion and for addressing the farmers' problems, loss reduction, and for sustainable agriculture development.

6.7 Government Strategy on Postharvest loss Reduction

Nepal has formulated several plan, policies, strategies, programs and projects for agricultural sector development for more than six decades. Pandey and Shayka (2016) mention government prioritized the horticulture sector with initiation of vegetable sector research and development since 1940 however, horticulture sector development is slow. Nepal agriculture policies and programs have more focused on cereal crops for food security purposes with less priority for the horticulture sector (Khatiwada 2020). In 1974, the agricultural department was successful in introducing many different types of fruits in Nepal (Khatiwada 2020). The horticulture research division in Nepal Agriculture Research Council (NARC) was functional only after 1993 with few infrastructures and facilities (ibid 2020). The 20 years Agriculture Perspective Plan, APP (1995-2015) was the first agriculture policy of Nepal, and currently Agriculture Development Strategies, ADS (2015-2035) is guiding agriculture sector. Significant attention received to the horticulture sector from APP and ADS has opened up space for its development, expansion, commercialization, and market linkage (Khadiwada et al 2022).

Kaini (2020) argues that even though Nepal vision for agriculture development through implementing policies and strategies like 20 years APP, National Agriculture Policy 2061 (NAP 2004), and ADS for agriculture development, still the agriculture progress is slow and difficult to take momentum. There are various reasons behind the difficulty in achievement of agricultural development that includes; Market structure development and regulation, control price/ government interventions on agriculture prices, input supply on time, protect farmers and producers from implementing minimum support price, crops insurance, access to agriculture credit, subsidize production inputs (Shrestha et al 2022). The government policies and strategies moreover focus on agriculture development through commercialization and increasing production since development and implementation of APP and NAP in 2004.

6.7.1 Agriculture Perspective Plan (1995-2015)

Agriculture Perspective Plan (APP) is a 20- years agriculture strategy implemented in 1995 for increasing annual agriculture contribution in national Gross Domestic Product (GDP). The APP is the first document accepted from the major political parties and from the bilateral and multilateral agencies for agriculture led poverty reduction (Devkota 2014). The APP was

developed for emphasizing technology-based green revolution in the country (Roka 2017). The APP had vision for poverty reduction through agriculture sector development, creating employment opportunities, transformation of subsistence agriculture into commercial and diversification of agriculture production. APP strategy for fruits and sericulture development as high value crop in marginal land as well as for soil conservation instead of cereal cropping with less production and productivity takes time for transformation (Devkota 2014). The APP was a national agriculture development strategy that vision for agricultural sector development through rural infrastructure development such as road, power, irrigation, technology development and input support (subsidy in fertilizer), and institutional development. Even after 28 years, high value crop cultivation, crop diversification and transformation of subsistence farming to commercial farming is still under the priority of agricultural development policy and strategy of Nepal. The strategies and pathway of APP is still significance.

6.7.2 Nepal Agricultural Policy, 2004

The agricultural sector development was under guidelines of Agricultural Perspective Plan in 2004. At the meantime, Nepal Agricultural Policy (NAP 2004) was formulated and implemented as a national agricultural policy with following basic aspects of APP, the agricultural sector development. The NAP 2004, implementation main purpose was felt need of economic liberalization, further to address sustainable development agenda that was set for the country and it is Millennium Development Goals (MDGs). The (NAP 2004) come into existence with a vision for sustainable agricultural development to uplifting farmers' livelihood through transformation of subsistence farming system into commercial farming. The purpose of the (NAP 2004) is to increase agricultural production and productivity through commercialization and crop diversification for production of marketable products and compete in the regional and global market. Therefore, achieving the aim, the NAP 2004 has various policies that include development in irrigation, agricultural road, technologies, electricity, agri-enterprise, hybrid seeds production and use, storage facilities , prioritize private sector involvement, training to farmers and women to improve efficiency. Even though, the NAP policy has not directly mention the agricultural produce loss reduction, the above mention policies are moreover helpful for postharvest loss minimization. Lack of adequate infrastructure is the major driving factors of postharvest produce loss that NAP prioritize. In addition, NAP focus on establishment of collection center in the potential production centers

for marketing of the produce, 'Haat Bazar' (Farmers' Market) promotion, development of well-equipped wholesale and seasonable markets to promote and market local produce to strengthen local economy are other positive aspects beneficent for loss minimization. After 20 years completion of APP, another Agriculture development Strategy, APP (2015-2035) implemented following the approach of APP and NAP.

6.7.3 Agriculture Development Strategy (2015-2035)

Agriculture Development Strategy (ADS) 2015-2035, prepared by Government of Nepal (GoN) with supports from multilateral International financial Institutions for agriculture transformation through commercialization and competitiveness. The ADS (2015-2035) formulated to facilitate economic growth acceleration needed for Nepal to upgrade into middle-income country status by 2022. The 20 years Agriculture Development Strategy implemented just after the end of APP from 2015 with a strategy that emphasize on agricultural transformation process that transform the economic structure of people based on agriculture to the industry and service that generate higher income. The value chain development included as the integral part of four pillars of the strategic framework of the ADS for the profitable commercialization. ADS emphasizes on strengthening agriculture linkages other strategies for rural poverty reduction. For example: promotion of non-farm activities based on agriculture will supposed to generate employment as well as support for agricultural produce promotion.

The ADS more focus on commercialization of agriculture, price, credit, marketing and input supply. Roka (2017) claims, ADS emphasis on small commercial farmers holding 1 to 5 hectare land, and fail to visualize the changing dynamic of Nepalese agriculture. This strategy has advocated open market economy even though about two third of population of the country is involved in agriculture, the productivity and competitiveness is minimal. Use of improved agro-technology is limited. The ADS prioritizes horticulture sector development through commercialization, value addition, and market linkage (Khatiwada et al.2022). ADS set up production specific commodities for commercialization and categorized particular places based on agro climatic condition, for example; apple in high hills, citrus fruits (lime, orange, and mandarin) in hills, mango, banana, litchi, in terai. Further, ADS focused on production increment of these crops through improving the postharvest handling and management and losses reduction. The previous strategy APP had not included value chains as an important step or strategy for agricultural development. The ADS emphasize on vegetable development value

chain through increasing production, marketing, institutional support, and through improving policies, regulatory framework, and institutions for vegetable sub-sector. (ADS 2015, 118). Further, ADS focus on improving vegetable productivity of smallholder farmers through providing technological guidelines for off-season vegetable production, training, production blocks development, and for postharvest handling and for improved vegetables marketing, appropriate grading, sorting, packaging, and collection center is promoted. Off-season vegetable call center establishment for market intelligence is another significant strategy of ADS. ADS promote public private partnership model (PPP) investment that includes public, private and cooperative sector for market infrastructure for example; on farm storage, cool storage, cold storage, existing market improvement and new ones establishment, agro industrial park for agro industry enterprise promotion, agro processing plants, and capacity building programs for management and governance.

ADS vision for competitive agricultural value chains to increase value added and benefits to smallholder farmers and agro enterprises, emphasize on capacity building, research and demonstrations. Plan for establishment of collection centers, small irrigation, processing facilities, and equipment, etc. at all three tiers of government (local level, district level and province level) to address farmers problems are positive aspects of ADS. The ADS is a guiding strategy that has emphasized on postharvest handling and management through promotion and advancement of postharvest technologies and value-chain infrastructure development (Khatiwada 2022). ADS present two programs for example; Value Chain development (VCD) and VCD-based Community Agriculture Extension Service Centers (CAESE) to bring fear and competitive environment in value chains that results value addition and smallholder farmers' benefits. The 10 years Prime Minister Agriculture Modernization Project (PMAMP) developed and implemented all over the country since 2016 under the Ministry of agriculture and Livestock Development (MoALD). The PMAMP is based on the principle of ADS that aims to increase smallholder farmers' income through boosting productivity, development in postharvest technology for reducing postharvest losses and improve market system and linkages. The fifteenth three-year periodic development plan of Nepal has also found supportive to the PMAMP through prioritization of agriculture sector development.

6.7.4 Fifteenth Three-Year Plan (2019/2020-2023/24)

The Fifteenth three-year plan is the first plan formulated with long-term vision, “Prosperous Nepal, Happy Nepali’ through economic growth from social, economic and physical infrastructure development, socioeconomic transformation, and equitable distribution of the resources and social justice. Agriculture being a main sector for economic development, the 15th plan vision for sustainable and self-reliant agriculture development through modernization and commercialization of the agriculture. Industrialization of agriculture sector though investment in agriculture for increasing production, productivity, and competitiveness of export oriented and market-driven production, achieve food sovereign and independent economy country. The plan states climate change, subsistence farming, rapid urbanization, arable land fragmentation and plotting, barren land, irrigation, and infrastructure development are the challenges for agricultural sector transformation. For achieving the goal of self-reliant economy, the plan has incorporated some policies of (NAP 2004) such as, market-oriented production and commercialization, cold storage establishment in every federal constituency, credit and insurance facilities to the agricultural produce, market information development, and value chain development in coordination with the local government. Cooperatives institutional capacity enhancement to ensure farmers involvement for increasing production and marketing policy has emphasized the cooperative’s importance to the farmers. As (NAP 2004) policy, the fifteenth plan has emphasized on production and productivity and has not mention about the postharvest reduction to ensure food availability, food security and farmer’s economic security.

6.8 Overview of Postharvest Interventions in Nepal

Nepal as a United Nations (UN) member has signed an agreement to support for sustainable development goals. Nepal has introduced and implemented sector specific policies, strategies, programs and projects. Nepal has previously realized the significance of postharvest losses reduction and had implemented a two-year pilot project Rural Save Grain Project (RSGP) in 1980. The RSGP was upgraded as a program with financial and technical support from the UN, FAO, and implemented till 1994. The RSGP was the first program introduced from the government of Nepal for reduction of postharvest loss on cereals (rice, maize and wheat). In

1992, increasing trend of high value crops commercialization and production, a separate division Postharvest Loss Reduction Division (PHLRD) was established for handling and storage of perishable commodities like fresh fruits and vegetables. In 2003, PHLRD was established as one of the separate twelve Directorates under DOA with new name Postharvest Management Directorate (PHMD). "The PHMD stopped functioning afterwards the state restructuring process into center, province, and local government" (Key informant, Farmers' commission). Under a technical cooperation project (TCP) of FAO, PHMD implemented "Reduction of postharvest losses in horticulture chains in SAARC countries" during 2014-2016, the project focused on particular vegetable postharvest loss reduction through supporting research activities, postharvest inputs support, and training (Khatiwada 2020)

The lists of various projects that had focused on postharvest losses directly and indirectly through their activities collected from the online source, VCDP publication and from literature review. 1980s green revolution initiation had emerged numerous projects but vegetable crops commercialization was less prioritized until "Vegetable Seed Production project (1980-1987)". This project was implemented in three phases (phase I, phase II and phase III) in which proper postharvest handling along with marketing concept was implemented in phase III after improved seeds introduction and commercial seed production in phase I and II respectively (Khadwada 2020).

Another two projects focused on postharvest interventions "New Kalimati Market Technical Corporation Project" and "Small Marketing Infrastructure Project" were implemented during 1995-2000 under financial support from the United Nations Capital Development fund. During 2008-2009 "Capacity building in agricultural marketing and market management" a technical cooperation project of FAO was launched which had published publication about market, and postharvest posters and training manual.

Since 2003, International nongovernmental organizations (INGOs) and private sector institutions started to contribute in postharvest handling and management through implementation of different projects. International Development Enterprises (IDE) and Winrock International (WI) joint project "Smallholder Irrigation Marketing Initiative"-2003, United State Agency for International Development (USAID) launched Nepal Economic, Agriculture, and Energy (NEAT) 2010-2013 to strengthen the foundations for rapid, sustained, and inclusive economic growth in which value chain and market access of vegetables was also focused. AVRDC-USAID launched "Postharvest Project in South and Southeast Asia" 2014-

2016 that focused on postharvest quality improvement through new verities, cold chain management and adaptation in low cost technology. Asia Food and Agriculture Cooperation Initiatives of Rural Development Administration South Korea launched a project "Establishment of Network and Model Manual to Postharvest Technology of Horticulture Crops" duration 2012-2018, to improve quality of different fruits and vegetables and to reduce postharvest losses. The government of Nepal has implemented various agricultural development projects as a partner with bilateral and multilateral organizations that includes; The United State Agency for International Development (USAID) project "Knowledge-based Integrated Sustainable Agriculture in Nepal (KISAN) I and II"; The Nepal Agriculture Development Program (NAMDP) /'Sahaj' phase 1 (2016-2020) and Sahaj (2020-2024) are some of the projects focused on agriculture to address postharvest loss.

6.8.1 Prime Minister Agriculture Modernization Project - 2016-2025

The Prime Minister Agriculture Modernization Project (PMAMP) is the largest agriculture project with estimation of NRs.130 billion and has been implemented since 2016 under Nepal government own internal investment with internal vision and mobilizing selected Nepal civil service employees that cover whole Nepal (PMAMP 2015). The project consists (58) Project implementation Unit (PIU), small commercial agriculture production center (pockets, 7657), development program, commercial agriculture production center (blocks, 1587), commercial agriculture production, and processing center (zones, 177) and development program and large commercial agriculture production and industrial center (super zone, 16) throughout Nepal. Ministry of Land Reform, Agriculture and Co-operatives of respective provinces and Agriculture Knowledge Centre (AKC) are supportive ministry and organization for project implementation. The PMAMP aims to incorporate the needs of the farmers and other stakeholders such as farming entrepreneurs, service providers, rural youths, agri-service agencies, agricultural sector officials through its activities and update data and information.

The Key informant, PMAMP shared project progress in addressing farmers' postharvest loss of the produce through separate program and activities such as awareness raising activities and distribution of plastic crates to the farmers. Furthermore, the PMAMP Dhading official added the project is providing support to the farmers for construction of cost-effective cold storage, electricity power cost used in operation of cold storage. This seems to be positive aspect of GoN in supporting the resource poor farmers for minimization of postharvest loss. PMAMP

annual and progress report 2021/22 state 366 postharvest center were established all over the project areas for agriculture commercialization postharvest produce management, handling and market management and other infrastructure including small transportation service, vehicle (tactor, single cabin jeep, pickup etc), primary processing center, storage center, grading, pre-cooling, weighting, packaging, labeling, display and sales stalls. PMAMP officer, Dhading expressed, "Currently we are more focused on providing training and awareness program, distribution of plastic crates to replace traditional carrying and transporting produce bamboo basket (DOKO) for postharvest loss minimization, establishing farmer centric and cost effective cold storage building, cash distribution to buy agricultural machinery such as hand tractor, and provide funding to different farmers' demand programs. PMAMP envisages separate program for postharvest loss but we are in process of implementation". This indicates PMAMP is one of the government initiations for addressing postharvest loss reduction. Similarly, through direct involvement, Nepal government completed "Value chain development of fruits and vegetables" (VCDP) in December 2022.

6.8.2 Value Chain Development of Fruits and Vegetables Project - 2018-2022

The Value chain Development of Fruits and Vegetables Project (VCDP) is relevant in addressing national agriculture policies and strategies in a sense that the project focus on increasing agricultural production and productivity prioritize postharvest research and infrastructure, development of well-structured value chain infrastructure so as to reduce postharvest loss of fruit and vegetables, and create market linkage with emphasis on commercialization and competitiveness. The Ministry of Agriculture and Livestock Development (MoALD) implemented Value Chain Development of Fruits and Vegetables Project (VCDP) 2018-2022 with the support from Korea International Cooperation Agency (KOICA) and UNDP (VCDP 2020). The VCDP implemented in Bagmati and Gandaki province and aims to focus on increasing incomes of smallholder farmers through increasing productivity, reducing postharvest losses by development in postharvest technology, and improving market system and linkages. This research study area Gajuri rural municipality is among the project implemented district of VCDP that focuses on fruit (banana) crop. In coordination and support, the VCDP has developed three 'Postharvest loss reduction management technology' for four different fruits (banana, sweet orange, lime and papaya), and

vegetables (potato, tomato and cauliflower). Moreover, VDCP produced 18 manuals on 'postharvest loss management' and 'technology dissemination strategies'. VCDP provides financial support for postharvest technology development equipment research. The VCDP emphasized SDG 2 (increase agricultural productivity, increase investment in research and extension service, SDG 8 (promotes sustainable economic growth and employment for agricultural development), SDG 12 (address food loss reduction along in production and supply chains, including post-harvest losses). Establishment of postharvest laboratory at the Nepal Agriculture Research Council (NARC) is another progressive step of the VCDP in postharvest loss reduction process. For postharvest loss reduction, fruit harvester as postharvest loss reduction technology was developed and introduced in the field, and commodity postharvest management factsheets were also published in local language for easily understandable (VCDP 2020).

According to the opinion of a key informant, VDCP official, "The VDCP is effective and need based project that government has implemented to address the farmers problems, capacitate farmers to get access to market and identify new one through market information, to make farmers aware from traders and intermediaries price manipulation, and support in postharvest loss reduction by using postharvest technological tools introduced by the VCDP". Further, Khatiwada and KC (2022) also write "the VCDP supported to generate smallholder farmers friendly appropriate postharvest technologies and for documenting significant postharvest interventions learning in VCD of fruits and vegetables". Even though there is need of separate study to explore the impacts of the VDCP on farmers' livelihood and support for postharvest loss reduction but the VCDP report data and information, literatures, and concerned project personnel reveal its significance in PHLR in Nepal.

6.9 Discussion

The government of Nepal formulated and implemented agriculture sector prioritize periodic plans, policy and strategy that directly and indirectly support in postharvest loss reduction. However, farmers' traditional knowledge and indigenous farming practices in terms of local seed preservation and cultivation, promotion of ecofriendly storage system have not incorporate that have great potential in postharvest loss minimization. Establishment of Agriculture Knowledge Center in all districts, increase farmers access to agricultural credit through cooperatives and microfinance at minimum percent, policy to establish at least one

storage house at each municipality, strengthening local market (Haat Bazar), and implementation of projects to minimization of postharvest loss are positive aspects of the state. In addition, government policy to establish at least one cold storage in the local level and provide subsidy in power supply use will benefit the farmers. However, government seems to focus on the establishment of modern storage facilities is not climate resilience and sustainable method. Therefore, traditional storage system such as 'Zero energy storage technique' if possible to establish cold storage with solar power system installed is good option for the irregular power supply area and no access to electricity area. Kaini (2020) present government strategies for agricultural sector development including subsidy on production inputs, technical services credit to agriculture sector, crop and livestock insurance, minimum profit guarantee/ minimum Profit Price Guarantee/ Minimum Support Price (MSP), linking farmers to markets, strengthen local market (haat bazar).

Government plan to establish fresh produce markets in all provinces will facilitate the farmers to sell their produce. Even though there are commodity-wise research and extension activities are prioritized but postharvest management of different horticulture produce still needs to produce. Overall, government policy, strategies and projects has plan for maximization of agriculture production and productivity but seems to address postharvest losses through strengthening market structure, provide minimum support price to the fruit and vegetable growing farmers. Government has to solve the problems of supply chain management of the vegetable market.

Chapter 7: Conclusion

In food value chain, each individual action is equally significant for food accessibility. However, the farmers act as the main contributor for producing quality and quantity of food to the world population. The farmers are more responsible than other stakeholders to bring food on plate to the consumers. The farming methods, choice of cultivation pattern, selection of seed crops, use of fertilizers, pesticides and insecticides, harvest handling and management including harvesting techniques, tools, harvesting timing, storage, packing and transporting all are important acts and responsibilities of the farmers to increase quality food production and availability that could result in postharvest loss minimization. Farmers' concern of food production is not sufficient but extra efforts is needed in producing quality produce for which appropriate harvest time, with using proper postharvest loss reduction technological tools is indispensable. In order to save produce from the physiological, mechanical, chemical, and physical damage the farmers every act is essential that help to reduce postharvest loss. On the other hand grading and sorting, proper packing and transporting are other tasks that farmers are responsible to perform so good quality produce reach to the consumers. Sustainable agriculture production is another task upon the farmers' shoulders to carry because 'agriculture is one of the contributors of GHG emissions' (FAO 2017). Therefore, farmers are more responsible for the produce, people, and the planet. The farmers from the study area are diversifying their agriculture systems by expanding the cultivation of traditional food crops and integrating vegetables and livestock with existing crops. The farmers are the main actors among the stakeholders of food chain. Nevertheless, the government policy, strategies, rules, regulations, and support measures are equally significant for regulating the acts of other stakeholders.

Increasing agricultural produce is not only way for feeding fast growing global population. Growing quality produce and saving what is produced is scientific, sustainable and cost-effective method that every country need to incorporate in their policy, planning and strategy. In the study area, the farmers seemed worried about the vegetable appropriate market price because more often their cost of production calculated higher than the given selling price. Even though, government display daily vegetable wholesale and retail prices, it is hardly followed by the trader which results a high gap between the farmers price and final consumers purchasing price. The value chain where price of produce keep on adding while farmers price keeps on decreasing due to vegetables loss during the transportation is another challenge to the farmers. Therefore, government ought to implement market support price for the produce that

is applicable to all value chain actors. The respondent farmers claim that due to entry of subsidized vegetables from India and China, they are unable to compete their products price and the intermediaries pressurize the farmers to decrease selling price as low as possible. This unhealthy competition and trader tendency are creating problems to the farmers therefore; the farmers are substituting the vegetable crops to oil crops. In such situation, government mission to make country self-sufficiency in vegetable and commercialization of agriculture sector could be difficult to realize. Increasing agricultural production is possible and not difficult if the farmers receive inputs supports, credit support from the government. The main problem is the market of the farmers' produce. Therefore, government policy and strategies should focus on saving what is already produced.

The agricultural labor shortage in the rural areas is hindering farmers in farming activities including field preparation to harvesting, sorting, packing and transporting to collection point, collection center and even at the local market for produce sell. Even though the road connectivity facilitates the households of study area but access to the entire farm land which is far, steeply, and sloppy is challenging. Absence of male member and presence of only elderly people, children, and female members in the family cause difficulty in sellable produce harvesting and transportation. In some place, the trader provides on-farm collection service such as in Benighat Rairang field area for orange collection is significant and most helpful to the smallholder farmers.

One of the respondent farmer has started to cultivate and produce less vegetable with a fear of selling difficulty due to labor shortage during harvesting, transportation and getting less market price for the vegetable. Therefore, the study area farmers apply a strategy to cultivate crops such as oil crops that need frequent care, reduce competition, and fulfill household consumption rather than producing large amount of seasonable vegetables. Khatun and Rahman (2018) suggested for postharvest management training, crop diversification, and fair price as important strategies for reducing postharvest losses at farm level. The farmers practicing multiple cropping are found less vulnerable in terms of income earned because when one crop does not grow well, or could not sell at profit margin in the market then other crops cover the loss on average and food availability (study field report).

For reduction of postharvest loss of fruits and vegetable, traditional postharvest handling and management is significant that helps to reduce agricultural produce losses by at least 5 percent (Adewoyin et al.2022). The pre-harvest activities are also equally necessary to

prevent quality loss and to control over production of seasonal vegetables. The large quantity seasonal vegetables supply in the market and the entry of subsidized vegetable from other countries are challenging the Nepalese farmers to sell produce in profit. Therefore, produce is left on the farm when farmers are not able to get even cost price of the produce that result loss. The research has acknowledged that in agriculture quality of produce is more significant than its quantity for the minimization of post-harvest loss along with postharvest handling knowledge and management and its practices. Further, government role is equally important for providing access to market for the farmers, create viable environment to sell the produce at fair price and timely availability of goods and services. The findings demonstrate how the postharvest handling and management influences farmers' socio-economic status and performances are causing postharvest loss. The respondents' response on farming practices, harvested loss, and climate change impacts validate that climate change also has a substantial influence on agricultural production and postharvest loss. Climate change Mitigation and adaptation. As Dahal (2010) claim strengthening agriculture sector is for increasing land productivity, diversifying the appropriate crops, increasing farmers' income, and transforming the social structure of the community, Government of Nepal should take significant role in postharvest loss reduction through addressing the smallholder farmers' problems.

Along with increased of fruits and vegetables production, the probability of increment of postharvest loss percentage is high. The farmers' attempt to save food from being loss is positive aspect in terms of economic loss and for sustainable use of scarce resources. The traditional technique of fruits and vegetable preservation such as vegetables fermentation, pickling, drying are ongoing practices are described well in the chapter six. The respondent farmers have been practicing these techniques for century for food availability purpose in year-round and for giving away purpose to their friends, relatives and to the neighbors. The traditional food preservation does not require additional preservatives and incorporates sugar, salt, turmeric powder, mustard oil, and rapeseed powder, green chili whole, sichuan pepper, red chili powder as natural preservatives therefore, the farmers claim no side effect recorded. Through food preservation method food can be stored for example canning, jam making, juicing, sauce or ketchup, tomato puree, tomato paste, crushing vegetables, freezing fruits and vegetables, drying and pickling are industrialized and available in global market. Therefore, there are great possibilities of postharvest loss reduction of fruits and vegetables. The

indigenous knowledge of fruits and vegetables pickling and drying is commercialized and industrialized at national level and international level in different brands. However, in canning and freezing fruits and vegetables is modern method of food preservation that is hardly practiced in Nepal. The global market of canned food is increasing rapidly and popular between the youngster and busy people. Moreover, high percentage of people out-migration from one county to another could be another reason for increasing demand of traditional preserved food for traditional taste. The industrialized and globalized of food preservation method is interesting part that need separate study. There is great possibility for the farmers to establish agribusiness enterprise that could strengthen economic status and able to save harvested produce from postharvest losses. The ADS (2015-2035) has vision for agro enterprises promotion to benefits smallholder farmers through emphasizes on capacity building, research and demonstrations. The government support and implementation is essential for entrepreneurship promotion that is beneficial for the farmers, postharvest loss reduction, and for sustainable agriculture development.

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Gallery

Oil Crop farming in Galchi, Dhading

Multiple Cropping in Study area

Mixed cropping Cauliflower, potato and leafy vegetables

Cabbage

Beans

Leafy Vegetables

Harvested White Radish

Harvested French Beans

Packed for Transportation

French Beans Packed for Transportation

Local Beans left at farm due to low market price

Unsold Brinjal at the farm

Traditional Bamboo Basket (DOKO)

Board Mustard Leaf Ready for Selling

Orange Farm

Orange Harvesting

Manual Grading Oranges

Ready for Pick up at collection Point

Collection Center

Transportation

Local Market on the highway

Me : Study area farm

Sun Drying Mustard leaf for Gundruk Making

Potato Seed Storage