

Rural Development Report 2019

Food Waste to Wealth

Post-harvest Loss from Farm Gate to Market



CIRDAP

ENABLING RURAL COMMUNITIES

**Centre on Integrated Rural Development for
Asia and the Pacific**

RURAL DEVELOPMENT REPORT 2019

**Food Waste to Wealth: Post-harvest Loss
from Farm Gate to Market**



CIRDAP

**Centre on Integrated Rural Development for Asia and Pacific
(CIRDAP), Dhaka**

Centre on Integrated Rural Development for Asia and the Pacific

Rural Development Report 2019

Food Waste to Wealth: *Post-harvest Loss from Farm gate to Market*

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Foreword

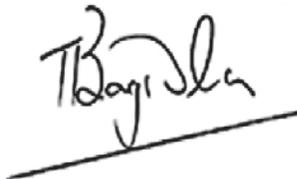
'Sustainable Development Goal 2: Zero Hunger' aims to ensure food security at global level. However, one of the major challenges in ensuring food security is Post-harvest losses, which is highly prevalent in CIRDAP member countries. This Post-harvest loss is a contributing element to the overarching concept of Food Waste and Loss.

This Rural Development Report is supposedly on Post-harvest loss alone. However, it would be deemed simplistic if addressed as such. To give weight to its importance pertaining to food security in the world, it has to be addressed under Food Loss and Food Waste theme.

The Report also explores ways in which these losses can be minimized in order to improve the lives and livelihood of the rural communities. This is brought about by innovative and improved technology and researched knowledge and practices.

I sincerely hope that CIRDAP Member Countries will take heed of some policies and good practices shared in the Report.

I, therefore, encourage all to commit in ensuring food security in rural communities in order to improve the quality of life of our rural people leaving no one behind.



Tevita G. Boseiwaqa Taginavulau
Director General
CIRDAP

December, 2019

Preface

Capturing emerging challenges in rural development, CIRDAP undertakes researches to identify gaps in rural development policies, practices and challenges amongst member countries. The Rural Development Report 2019, Waste to Wealth; Post-Harvest Food Loss from Farm Gate to Market, CIRDAP's fifteenth biannual Rural Development Report deals with Post-Harvest food losses and the current status and future perspectives in connection with rural livelihood in Asia and the Pacific. The Centre prepares this publication as part of its efforts to share knowledge and experiences, promote regional cooperation, and support and further the effectiveness of IRD programmes in the Asia-Pacific region.

The Centre on Integrated Rural Development for Asia and the Pacific (CIRDAP) is an Intergovernmental Organization mandated to promote Integrated Rural Development (IRD) in Asia-Pacific through regional cooperation. CIRDAP has 15-member countries namely Afghanistan, Bangladesh (Host State), Fiji, India, Indonesia, Iran, Lao PDR, Malaysia, Myanmar, Nepal, Pakistan, Philippines, Sri Lanka, Thailand and Vietnam.

The Centre's goal is to meet the felt needs of the developing states and act as a servicing institution for promoting Integrated Rural Development (IRD) in the region. CIRDAP promotes regional cooperation, operating through designated contact ministries and link institutions in member-states and plays a supplementary and reinforcing role in supporting and furthering the effectiveness of IRD programmes in Asia and the Pacific region.

Acknowledgements

Our greatest appreciation is extended towards all of our Link Institutes and Link Ministries in CIRDAP 15 member countries for providing us with necessary information enabling us to put together this Rural Development Report 2019 on Post-harvest Losses.

We acknowledge the continuous advice of our Director General to ensure that this report materializes. Acknowledgement is also directed towards staff members in the Research Division for compiling the report; staff in the Office of the Director General in the final editing process.

Finally we acknowledged Prof. Dr. M. Zulfikar Rahman of Bangladesh Agricultural University (BAU), Mymensing, Bangladesh for his contribution towards the Report.

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Acronyms

AARDO	: African-Asian Rural Development Organization
ASEAN	: Association of Southeast Asian Nations
CIRDAP	: Centre on Integrated Rural Development for Asia and the Pacific
CMC	: CIRDAP Member Country
CPF	: Country Programming Framework
DC	: Developing Country
EU	: European Union
FAO	: Food and Agriculture Organization of the United Nations
FL	: Food Loss
FSC	: Food Supply Chain
FSFS	: Food Security and Food Safety
FW	: Food Waste
GAP	: Good Agricultural Practices
GHG	: Greenhouse Gas
GHP	: Good Handling Practices
GMP	: Good Manufacturing Practice
HACCP	: Hazard Analysis Critical Control Points
IFAD	: International Fund for Agricultural Development
IRD	: Integrated Rural Development
JICA	: Japan International Cooperation Agency
LDC	: Less Developed Countries
MAP	: Modified Atmosphere Packaging
MARDI	: Malaysian Agricultural Research and Development Institute
NAP	: National Agricultural Policy
NFP	: The National Food Policy
OSP	: One Strategic Plan of United Nations
PHH	: Post-Harvest Handling
PHL	: Post-Harvest Loss
PHLM	: Post-Harvest Loss Management
PHO	: Post-Harvest Operation
PLA	: Postharvest Loss Assessment
RDR	: Rural Development Report
SAARC	: South Asian Association for Regional Cooperation
SDG	: Sustainable Development Goal
SME	: Small and Medium Enterprises
VC	: Value Chain
WFP	: World Food Program
WHO	: World Health Organization
ZHC	: Zero Hunger Challenge



Executive Summary

Food embodies much more than what is on our plates. It is, therefore, important that we recognize, appreciate and respect the value of food. This sentiment draws us to the issue of Food Security, an important component in achieving the Sustainable Development Goals (SDGs) through SDG 2 which seeks to “end hunger, achieve food security and improved nutrition and promote sustainable agriculture”.

Food loss has been identified as one of the major challenges in achieving food security as it accounts to about 30-50% globally. “Food loss” refers to the decrease in edible food mass or nutritional value of food (FAO, 2013), whilst “Post-harvest Loss” (PHL) refers to the loss of food in terms of matter or nutrition that incurs during harvesting, handling, sorting, storing, processing, packaging and marketing (Mrama and Rolle,2002).

Global food losses and wastage amount stands between one-third (FAO, 2016) and one-half (Anonymous, 2013) of the total produced worth approximately \$680 billion in industrialized countries and around \$310 billion in developing countries. The industrialized and developing countries are wasting approximately comparable amounts of food of 670 and 630 million tons, respectively.

Asia’s position in the global food market tilts heavily towards demand due to its huge population and limited agricultural resources. With only one-fifth of the world’s agricultural land, the region hosts more than half of the global population. Asia has achieved significant production improvements over the last 50 years but produces lower yields compared to most other regions. These issues are beginning to be challenged and addressed through market-oriented approaches and corporate farming to satisfy a growing population featuring rising income levels, urbanization, demand for higher food quality and environmental concerns. Nevertheless, the region has experienced food loss and wastage as well.

Food loss and food waste is really, really bad for the environment. It takes a land mass larger than China to grow the food each year that is ultimately never eaten – land that has been deforested, species that have been driven to extinction, indigenous populations that have been pushed out, soil that has been degraded – all to produce food that we then just throw away. In addition, food that is never eaten accounts for 25% of all fresh water consumption globally. Every which way to look at it, food loss and food waste is a major culprit in destroying our planet, and in fact if food waste were a country, it would be the third largest emitter of greenhouse gases after China and the USA. These losses also lead to wastage of human effort, farm inputs, livelihoods, investments and scarce resources such as land and water (WRI, 1998).

It is therefore important for growers, packers, transporters, shippers, and retailers to maintain the quality and quantity by having required infrastructures, markets, knowledge and skills and compliance with standard processes throughout the supply chain to ensure least food loss. There is a need to have good transport system, packing and storage facilities, technological innovations. There should also be available consistent markets which provide fair prices. All stakeholders along the supply chain need to have appropriate knowledge and skills to ensure proper harvesting, handling, movements of the produce and marketing mechanisms.

Given the challenges and opportunities available in addressing food losses, this Report will focus on the following:

- (i) Status of post-harvest food losses at the global and regional level (Asia-Pacific)
- (ii) The nature and extent of food losses from farm gate to market for CIRDAP Member Countries (CMCs)

- (iii) The challenges and opportunities in addressing food losses in CMCs
- (iv) The food loss policies and practices in CMCs
- (v) Recommendations and a good model for reducing post-harvest losses

Here in this report, Chapter One covers the introductory part to clarify the context. Chapter Two sheds light on the global status of the different aspects of post-harvest losses. Chapter Three provides the nature and extent of various aspects of the post-harvest losses in CMCs. Chapter Four discusses the policies and practices adopted by CMCs and its effects in reducing food losses. Chapter Five analyzes and explores the way forward and recommendations to address food losses in CMCs as well as developed a model on the enabling environment framework to address an appropriate value chain to minimize food losses.

Reducing Food Losses and Wastage is strictly a matter of enforcing strong enabling Policies. These policies should support human and institutional capacities. Human capacities include educating the farmers in quality management, safety assurance and loss reduction. This should be supported by strengthened educational and research institutions to include extension approaches within their post-harvest mechanism. The policies should support the organization of smallholders for capacity development and better access to improved technologies and practices; and promote the facilitation of the establishment of national and regional networks for information and technology exchange on post-harvest systems development.

The Way Forward to reduce postharvest losses rests best on the following: Formulating policies and escalating investments to build up infrastructures for food waste and loss management; and Governments' policies improvement for PHL reduction to support the development and adaption of applicable postharvest management technologies. Improving on-farm post-harvest practices; capacitating research and development institutions; improving access to information and capacity building; Increasing investment to develop infrastructures for market and value chain development ultimately lead us to a better world with proper food security.

Introduction

1.0 Background

Reducing Global Hunger is Goal Number 2 in the SDG (2030) Framework. World Hunger is on the rise; yet, every year around the globe an estimated 1.3 billion tons of food is lost and wasted¹ i.e. 1/3 of all food produced for human consumption. In an age where almost one billion people go hungry, this is unacceptable. Food loss and waste (FLW) represent a misuse of the labour, water, energy, land and other natural resources that went into producing it. It is a system – “The Food System” which includes all those activities involving the production, processing, transport and consumption of food. Following the FAO definition, a food system encompasses all the stages of keeping us fed: growing, harvesting, packing, processing, transforming, marketing, consuming and disposing of food (CFS, 2016). The most common food system is the agro-industrial food system that is global. It is dominated by a few multinational corporations through vertical integration. This is a very complex system with a long supply chain and it has a lot of processed foods. Food losses and waste are the result of ineffective functioning of food systems.

We are all committed to achieving the Sustainable Development Goals. A key goal we have set for ourselves is to attain zero hunger by 2030. Managing agriculture and food systems in a sustainable manner is key to reaching our shared goals. We have made these commitments knowing that we already produce enough food to feed every one, although almost 800 million people are still suffering from hunger. At the same time, more than 2 billion people are “over nourished,” either overweight or obese. The food systems have not performed in line with our expectations (Silva, 2016).

With growing resource constraints and the need to increase global agricultural production by 60 percent by the year 2050, reducing losses and waste becomes a key element in sustainable global development. To increase food availability, food loss and waste reduction is in principle far more efficient than expanding food production. Hence the global community has agreed on the Sustainable Development Goal number 12 (SDG 12), and identified a specific target (12.3) aiming to halve per capita global food waste and food losses by 2030.

For the purpose of this report, the title- “*Food Waste to Wealth: Post-harvest Loss from Farm Gate to Market*” is crafted to represent the CIRDAP Policy Bodies concern of food losses and wastage in its fifteen member countries consistent with other developing countries most of which happen from the farms right to consumption stage. Since the report takes into consideration global perspective as bearings, it has to discuss food loss and waste both concepts encompass post-harvest loss.

1.1 Definitions

The causes of food loss and food waste are numerous and occur at the stages of producing, processing, retailing and consuming. We are over 7 billion people on this planet, of which 925 million are starving. Roughly one third of the food produced in the world for human consumption every year – approximately 1.3 billion tons – gets lost or wasted. Yet, food loss and waste account for about 4.4 giga tons of greenhouse gas emissions

¹(FAO, <http://www.fao.org/food-loss-and-food-waste/en/>)

(GHG) per year. For the purpose of clarity in communication and expressions of meanings, this section proposes to expound on the definitions of key concepts of the report.

- (i) “Food loss” is defined as food available for human consumption, but not consumed, thus considered food loss. Food loss refers to any food that is lost in the supply chain between the producer and the market. This may be the result of pre-harvest problems, such as pest infestations, or problems in harvesting, handling, storage, packing or transportation. Some of the underlying causes of food loss include the inadequacy of infrastructure, markets, price mechanisms or even the lack of legal frameworks. Tomatoes crushed during transport because of improper packaging are one example of food loss. One of the SDG targets states that, by 2030, we should reduce food losses along production and supply chains, including post-harvest losses, and cut in half per capita global food waste at the retail and consumer levels. Food losses further refer to the decrease in edible food mass throughout the part of the supply chain that specifically leads to edible food for human consumption. It takes place at production, postharvest and processing stages in the food supply chain and right at the end of the food chain (retail and final consumption). Food loss or waste ends up wasting nearly a quarter of our water supply in the form of uneaten food or over \$172 billion in wasted water. When food is disposed in a landfill, it rots and becomes a significant source of methane – a potent greenhouse gas with 21 times the global warming potential of carbon dioxide. Food is lost and wasted in many ways:
 - (a) Fresh produce that deviates from what is considered optimal in terms of shape, size and colour, for example is often removed from the supply chain during sorting operations.
 - (b) Foods that are close to, at or beyond the “best-before” date are often discarded by retailers and consumers.
 - (c) Large quantities of wholesome edible food are often unused or left over and discarded from household kitchens and eating establishments.
- (ii) “Food waste” refers to food appropriate for human consumption being discarded, whether or not after it is kept beyond its expiry date or left to spoil. Food waste occurs at the food chain (retail and final consumption) and relates to retailers and consumers behavior (FAO, 2013). Food wastage refers to any food lost by deterioration or waste. The term “wastage” includes both food loss and food waste (Kiaya, 2014). Food waste refers to the discarding or alternative (non-food) use of food that is safe and nutritious for human consumption. Thus they are rather called “food waste”, which relates to retailers’ and consumers’ behavior (Parfitt et al., 2010). FAO defines food losses and waste as a ‘decrease in quantity or quality of food’, i.e. a reduction in the availability of food, a decline in its nutritional and/or economic value, and/or deterioration in food safety.
- (iii) “Post-harvest losses” in the post-harvest loss (PHL) system refer to the quantitative and qualitative loss of food in various post-harvest operations (Sawicka, 2019) including harvesting, handling, storage, processing, packaging, transportation and marketing (Mrema and Rolle, 2002). Postharvest loss can also be defined as the degradation in both quantity and quality of a food production from harvest to consumption. Quality losses include those that affect the nutrient/caloric composition, the acceptability, and the edibility of a given product. These losses are generally more common in developed countries. Quantity losses refer to those that result in the loss of the amount of a product. Loss of quantity is more common in developing countries (Kitinoja and Gorny, 1999). A recent FAO report indicates that at global level, volumes of lost and wasted food in high income regions are higher in downstream phases of the food chain, but just the opposite in low-income regions where more food is lost and wasted in upstream phases (FAO, 2013).

Not only are losses clearly a waste of food, but they also represent a similar waste of human effort, farm inputs, livelihoods, investments and scarce resources such as water (WRI, 1998). Post-harvest losses for horticultural produce are, however, difficult to measure. In some cases everything harvested by a farmer may end up being sold to consumers. In others, losses or waste may be considerable. Occasionally, losses may be 100%, for example when there is a price collapse and it would cost the farmer more to harvest and market the produce than to plough it back into the ground. Use of average loss figures is thus often misleading. There can be losses in quality, as measured both by the price obtained and the nutritional value, as well as in quantity.

Since the report is on **Post-harvest loss from Farm Gate to the Market**, its discussion under the Food Loss and Food Waste theme gives prominence to its relevance to the Food Security of the world debate.

1.2 Statement of the Problem

There is a need for the CIRDAP Member Countries to access data on the Asia Pacific region status of Food Security. This would be determined by investigating the Food Loss and Wastage issues as a result of post-harvest loss from farm gate to market from all CIRDAP Member Countries. Postharvest losses may occur at any point in the marketing process, from the initial harvest through assembly and distribution to the final consumer. The causes of losses are many, physical damage during handling and transport, physiological decay, water loss, or sometimes simply because there is a surplus in the market place and no buyer can be found (Anonymous, Undated).

Losses are high in many tropical countries, because of the inherent difficulty of collecting and transporting small quantities of produce from numerous small farms, and trying to collect these into a large enough quantity for efficient domestic marketing or for export. Even if large shipments can be collected together, the produce is often highly variable in size and quality, so that it is difficult to apply standardized grading and storage procedures. In tropical and subtropical countries, the warm, humid climate adds more stress and accelerates the decay of tropical produce. Postharvest losses of vegetables and fruits in most Asian countries are so high, and the causes of these losses are so diverse, that a great deal of research and training is needed if prevention measures are to be improved. The need for improvement is shown by the fact that in developing countries where there is still a poor infrastructure and a lack of marketing facilities, postharvest losses of fresh produce range from 20% to 50%.

Farmers and food sellers have been concerned about losses since agriculture began. Yet the problem of how much food is lost after harvest to processing, spoilage, insects and rodents, or to other factors takes on greater importance as world food demand grows. Cutting postharvest losses could, presumably, add a sizable quantity to the global food supply, thus reducing the need to intensify production in the future. Thus, the need for a comprehensive record to provide the platform of discussions. That is the reason for this report. We need comprehensive collection of data from CIRDAP Member Countries sharing with us their good practices and challenges regarding how a pattern of mitigating process could be crafted for adoption.

1.3 Purpose and Objective of the Report

The Goal of this report proposes to investigate and discuss Post-Harvest Losses (PHLs) of Farm Produce from the Farm gate to the Market. Focus will first start at global level before attending CIRDAP Member Countries. Conceptually, the post-harvest issue includes all points in the value chain from production in the field to the food being placed on a plate for consumption. Postharvest activities include harvesting, handling, storage, processing, packaging, transportation and marketing. The report crafts a conceptual frame work as to how the process could be understood and practised.

- (a) As Objectives, the report proposes to:
 - (i) Investigate the Status (state controlled and open market) of food waste through losses during post-harvest to market at global and regional (Asia-Pacific).
 - (ii) Determine the nature and extent of food losses from farm to market for CIRDAP Member Countries (CMCs).
 - (iii) Identify challenges and opportunities(good practices) in CMCs to mitigate food losses.
 - (iv) Examine the policies and practices in CMCs relevant to food waste through food losses.
 - (v) Analyze and Explore the way forward - the opportunities and addressing the challenges.

1.4 Limitations of the Report

In a single study, it may not be including all the issues of postharvest; especially when the concern is about the different countries and regions covered in the same report. This report has at least the following limitations in content and presentation.

- (i) The report depended heavily on the secondary information. But primary investigation and their utilization would be of much more practical.
- (ii) Data on various aspects of PHLs were not duly available. Hence, there remained some limitations in depicting reality of the scenarios.
- (iii) A long time series data could be of very utility in showing the temporal trend in concerned development of stories. But it was not satisfactorily possible because of information deficiency.
- (iv) Data unavailability from the government websites of different countries
- (v) Unavailability of information on the consequences after implementation of various policies and regulations regarding postharvest management of agricultural produces. Also faces problem of data inadequacy on monitoring the processes in implementation.

1.5 Methodology

The report is mainly qualitative relying on secondary information collected from various types of documents like books, journals, research papers, and popular reports from national and international organizations, internet, periodicals, policies, and others. Country papers, national data base, FAOSTAT and other websites are used to collect data and information for this paper.

As a form of analysis, the report follows a qualitative data analysis to interpret patterns and themes appearing in the information collected. These patterns should be sufficient to craft a conceptual framework on how food loss and food waste could be reduced.

1.6 Organisation of Report Chapters

- (i) Chapter One covers the Introduction to clarify the context and key concepts used in the Report as well as the scope and limitations of the study.
- (ii) Chapter Two sheds light on the global status of the post-harvest loss where the extent, type, cost, causes, environmental impacts, challenges and measures to address food losses. Food loss is a current global phenomenon and the extent to food loss in global and regional picture is astonishingly high. Therefore this Chapter also provides a comparative status of food losses at global and regional level in order to provide a clear understanding of the status of food losses in CMCs.
- (iii) Chapter Three provides an overview of the post-harvest losses in CMCs. It deals with the nature and extent of losses and related issues like cost, major causes, effects, challenges, and ways to minimize the post-harvest food losses in CMCs.
- (iv) Chapter Four discusses the policies and practices adopted by CMCs and its effects in reducing food losses.
- (v) Chapter Five analyses and explores the way forward and recommendations to address food losses in CMCs in two different developed models. One on the enabling environment framework, the other to address an appropriate value chain to minimize food losses.



Source: <https://www.ghanabusinessnews.com/2018/09/04/post-harvest-losses-not-acceptable-gt/c/>
<https://www.thehindu.com/news/national/tamil-nadu/poor-arrivals-push-up-banana-prices/article4319108.ece>



Source: <https://sriankamirror.com/news/10205-rs-18-billion-annual-loss-from-post-harvest-waste>



Pirture : Some post-harvest food losses photos

Global Status on Food Loss and Food Waste



Global Status on Food Loss and Food Waste

2.0 Introduction

Food loss and wastage occur at all stages of the food supply chain or value chain. In low-income countries, most loss occurs during production, while in developed countries much food – about 100 kilograms (220 lb) per person per year – is wasted at the consumption stage (*Gustavson, 2011*). Globally, around one-third of all food produced is lost or wasted along the food chain, from production to consumption (HLPE, 2014). In a world where hundreds of millions of people go hungry, that is a stark indication of the inefficiency of current food systems.

Quantifying trends in food loss and waste is not easy because food supply chains are long involving many actors, including small farmers, transporters, processors, retailers and households. The difference between food loss and waste is not cut and dry, it is seen as accidentally occurring for reasons not under the direct control of the agents concerned, such as inadequate technology, lack of knowledge and skills, poor logistics and malfunctioning markets, while it is characterized by an element of intended or unintended behavior, i.e. the removal of food fit for consumption by choice or negligence. Although food loss is often associated with final consumption, the deliberate discarding of food may occur at all stages of the supply chain.

Global food losses and wastage amount stands between one-third (FAO, 2016) and one-half (Anonymous, 2013) worth approximately \$680 billion in industrialized countries and around \$310 billion in developing countries. The industrialized and developing countries are wasting approximately comparable amounts of food in 670 and 630 million tons, respectively. Usually fruits and vegetables, as well as tubers and roots, have the highest level of losses compared to all food groups.

In North America, Europe, Japan and China, around 15 percent of food is lost or wasted in the distribution and consumption stages. This percentage is lower in North Africa and Central Asia (11 percent) and much lower in Latin America, South and Southeast Asia and sub-Saharan Africa (5.9 to 7.8 percent). In contrast, North America, Europe, Japan and China lose or waste only around 15 percent of food in the harvest and post-harvest stages. In sub-Saharan Africa, where food losses and waste are particularly high at 36 percent, some 5.9 percent occurs in the retail and consumption stages, while more than 30 percent occurs in the harvest, post-harvest and processing stages.

Global quantitative food losses and wastes during the year are around 30% for cereals; 40–50% for root crops and fruit and vegetables; 20% for oil seeds, meat, and dairy products; and 35% for fish. Every year, consumers in rich countries lose almost as much food (over 220 million tons) as the total net food production in sub-Saharan Africa (around 230 million tons). The entire amount of food lost or wasted annually is equivalent to more than half of the world's annual crop production (about 2.3 billion tons per year). Waste per capita in Europe and North America is 95–115 kg/year, while consumers in sub-Saharan Africa, South Asia, and Southeast Asia throw away only 6–11 kg/year.

In all regions, except South and Southeast Asia, food losses and waste account for more than 30 percent of food originally intended for human consumption. However, the extent of losses and waste along the food supply chain differs across regions (HLPE, 2014).

Food losses and waste are caused by different factors found at 3 different levels:

- (i) Micro-level causes resulting from the actions of agents at the same stage of the food supply chain (e.g. poor harvest scheduling and timing, poor harvest practices, careless handling of produce, lack of appropriate storage space, lack of transportation facilities, consumer behavior).
- (ii) Meso-level causes related to a whole food supply chain, i.e. decisions or lack of decisions of agents in that particular chain (e.g. poor coordination, too long chains, failure to meet product standards, pesticide-contaminated processed products). Uncertainty about weather and market conditions, and weak institutional frameworks, also contribute to losses. Each year in Africa, around 13 million tons of cereals, or more than 15 percent of total cereal production, are lost during post-harvest operations.
- (iii) Macro-level causes arising from the overall socio-economic environment, such as lack of infrastructure, inadequate legislative frameworks and price incentives and subsidies that promote excess production (HLPE, 2014). In low income countries, significant levels of food losses occur upstream, at harvest and during post-harvest handling, owing to poor infrastructure, low levels of technology, a limited knowledge base and lack of investment in production. Food losses also tend to be caused by managerial and technical constraints in harvesting, storage, transportation, processing, packaging and marketing. The greatest losses occur in small- and medium-scale agricultural and fisheries production and processing sectors.

As per FAO estimates, the key facts on food loss and waste are:

- (i) Roughly one third of the food produced in the world for human consumption every year — approximately 1.3 billion tonnes — gets lost or wasted.
- (ii) Food losses and waste amount to roughly US\$ 680 billion in industrialized countries and US\$ 310 billion in developing countries.
- (iii) Industrialized and developing countries dissipate roughly the same quantities of food — respectively 670 and 630 million tonnes.
- (iv) Cereals, Fruits and vegetables, plus roots and tubers have the highest wastage rates of any food.
- (v) Global quantitative food losses and waste per year are roughly 30% for cereals, 40-50% for root crops, fruits and vegetables, 20% for meat and dairy plus 35% for fish.
- (vi) Every year, consumers in rich countries waste almost as much food (222 million tonnes) as the entire net food production of sub-Saharan Africa (230 million tonnes).
- (vii) The amount of food lost or wasted every year is equivalent to more than half of the world's annual cereals crop (2.3 billion tonnes in 2009/2010).
- (viii) Per capita waste by consumers is between 95-115 kg a year in Europe and North America, while consumers in sub-Saharan Africa, south and south-eastern Asia, each throw away only 6-11 kg a year.
- (ix) Total per capita food production for human consumption is about 900 kg a year in rich countries, almost twice the 460 kg a year produced in the poorest regions.
- (x) In developing countries, 40% of losses occur at post-harvest and processing levels while in industrialized countries more than 40% of losses happen at retail and consumer levels.
- (xi) At retail level, large quantities of food are wasted due to quality standards that over-emphasize appearance.
- (xii) Food loss and waste also amount to a major squandering of resources, including water, land, energy, labor and capital and needlessly produce greenhouse gas emissions, contributing to global warming and climate change.

2.1 Extent of food losses

Today, a third of the planet's food— enough to feed two billion people goes to waste. Food is wasted at every stage from farm where unpicked, "ugly" produce rot in fields. It happens in grocery stores, where workers reject blemished, but edible, fruits and vegetables. And it happens in our own homes, where we ignore leftovers and trash perishables before they've expired.

Loss of food is a moral issue. And as National Geographic points out, we could use all this wasted food to feed 800 million starving worldwide twice. The magazine recently looked at data from the Food and Agriculture Organization (FAO) of the United Nations. Here is how they rank, with percentages of how much we waste globally every year. The world wastes a staggering amount of food —the breakdown by types stated by Garfield (2016):

- (i) Milk, yogurt, and cheese — 17.1%
- (ii) Chicken, beef, and pork — 21.5%
- (iii) Lentils, green peas, chickpeas, and seeds that make oil - 22.1%
- (iv) Cereal, bread, and rice — 29.1%
- (v) Tuna, salmon, shrimp, and other seafood - 34.7%
- (vi) Fruits and vegetables — 45.7%

Cereals comprise the largest share of global food loss and waste by caloric content—53 percent. Meat is a relatively small share—7 percent. However, not all loss and waste is created equal. The relatively large environmental impacts of meat in terms of greenhouse gas emissions, land use, and water consumption per calorie combined with the high economic costs of meat suggest that reducing meat loss and waste should receive at least as much attention as other commodities, despite comprising a smaller share of caloric losses. Whether one measures food loss and waste in terms of calories or weight highlights different food commodities. Whereas cereals comprise the most food loss and waste relative to other food commodities on a caloric basis, fruits and vegetables are the largest source of loss and waste on a weight basis as shown in following figure. This variance primarily results from differences in water content; much of the lost and wasted weight in cereals, fruits and vegetables is water (Lipinski et al., undated).



Figure 1: Share of global food loss and waste by commodity

As per SAVE FOOD: Global Initiative on Food Loss and Waste Reduction report of FAO stated the types and percentage of food loss can be seen from the following figures:²

- (i) Cereal food loss: 30%
- (ii) Fruits and vegetables loss: 45%
- (iii) Oilseed and pulses loss: 20% and
- (iv) Roots and tubers loss: 45%

2.2 Types of Food Loss

Five system boundaries were distinguished in the food supply chains (FSC) of vegetable and animal commodities. Food loss/waste were estimated for each of these segments of the FSC. The following aspects were considered.

Vegetable commodities and products

- (i) Agricultural production: losses due to mechanical damage and/or spillage during harvest operation (e.g. threshing or fruit picking), crops sorted out during post-harvest operation etc.
- (ii) Postharvest handling and storage: including losses due to spillage and degradation during handling, storage and transportation between farm and distribution.
- (iii) Processing: including losses due to spillage and degradation during industrial or domestic processing, e.g. juice production, canning and bread baking. Losses may occur when crops are sorted out if not suitable to process or during washing, peeling, slicing and boiling or during process interruptions and accidental spillage.
- (iv) Distribution: including losses and waste in the market system, at e.g. wholesale markets, supermarkets, retailers and wet markets.
- (v) Consumption: including losses and waste during consumption at the household level.

In 1974, FAO hosted the World Food Conference which called attention to the linkage between reduction of post-harvest losses and food security and as a follow-up, created a special action programme aimed at halving food losses. The fact that this objective has yet to be met indicates that market logic alone cannot trigger the needed change, especially when investments are required.

It is estimated that the total of global food loss and waste to around one third of the edible parts of food produced for human consumption, amounting to about 1.3 billion tons (1.28×10⁹ long tons; 1.43×10⁹ short tons) per year. As the following table shows, industrialized and developing countries differ substantially. In developing countries, it is estimated that 400–500 calories per day per person are going to waste, while in developed countries 1,500 calories per day per person are wasted. In the former, more than 40% of losses occur at the postharvest and processing stages, while in the latter, more than 40% of losses occur at the retail and consumer levels. The total food waste by consumers in industrialized countries (222 million tons or 218,000,000 long tons or 245,000,000 short tons) is almost equal to the entire food production in sub-Saharan Africa (230 million tons or 226,000,000 long tons or 254,000,000 short tons). A 2013 report from the British Institution of Mechanical Engineers (BIME) likewise estimated that 30–50% (or 1.2–2 billion tons or 1.18×10⁹–1.97×10⁹ long tons or 1.32×10⁹–2.20×10⁹ short tons) of all food produced remains uneaten.

Today, thanks to concerted surveys commissioned by FAO in 2011 and 2013, we can quantify the total of global food loss and waste (referred to as food wastage), as well as how the impact of that loss and waste compounds through the accompanying

² (<http://www.fao.org/save-food/resources/keyfindings/infographics/roots/en/>)

waste of the natural resources used to produce it. As shown in Table 2.1, this impact can include GHGs emissions during production, unduly occupied land, unnecessary water usage and loss of biodiversity.

In addition, a considerable amount of GHGs are emitted at a later stage in the supply chain, mainly due to methane emissions from food dumped in landfills or from carbon dioxide emitted by waste that is incinerated.

Table 2.1 Global scenario of food loss

Food loss and waste per person per year	Total	At the production and retail stages	By consumers
Europe	280 kg (617 lb)	190 kg (419 lb)	90 kg (198 lb)
North America and Oceania	295 kg (650 lb)	185 kg (408 lb)	110 kg (243 lb)
Industrialized Asia	240 kg (529 lb)	160 kg (353 lb)	80 kg (176 lb)
sub-Saharan Africa	160 kg (353 lb)	155 kg (342 lb)	5 kg (11 lb)
North Africa, West and Central Asia	215 kg (474 lb)	180 kg (397 lb)	35 kg (77 lb)
South and Southeast Asia	125 kg (276 lb)	110 kg (243 lb)	15 kg (33 lb)
Latin America	225 kg (496 lb)	200 kg (441 lb)	25 kg (55 lb)

(Source: Gustavson et al., 2011)

2.3 Cost of Food Losses

Approximately 30% of food produced for human consumption around the world is either lost or wasted each year is equivalent to 1.3 billion tons of food, USD 1 trillion in economic costs. Around USD \$700 billion in environmental costs and around USD \$900 billion in social costs. Food loss and waste represents economic losses for all actors along with food supply chains, including end consumers. It also represents a highly inefficient use of resources (e.g. labour, water, energy and land) as well as avoidable climate change and social impacts. Thirty percent of the global food supply is wasted - the retail equivalent of \$1 trillion of food each year, says the Food and Agriculture Organization (FAO) of the UN.

The FAO's Food Wastage Footprint project explains that, in addition to the retail cost of food lost, another \$700 billion is also thrown out in natural resources, including \$172 billion in wasted water, \$42 billion in cleared forest and \$429 billion in related greenhouse gas costs.

Wasted food results in \$150 billion in human health costs related to the use of pesticides (which also implies that the health costs of using chemicals on the 70% of food we actually eat total at least an additional \$350 billion a year). \$280 billion in loss of livelihoods (as natural resources become scarcer) is also tossed out the window when we throw away food. In 2017, Australia had the world's largest food waste per capita, with some 361 kilograms of food wasted per person. On the other end of the spectrum that year, China and Greece had the world's lowest food waste per capita, at 44 kilograms wasted per person.

We need to stop wasting food because wasting food means wasting money, labour and resources such as energy, land and water that go into producing the food. According to that nearly, 30 percent of all available agricultural land in the world - 1.4 billion hectares - is used for produced but uneaten food. The global blue water footprint of food waste is 250 km³ that is the amount of water that flows annually through the Volga or 3 times Lake Geneva. Response to the problem of food waste at all social levels has varied hugely, including campaigns from advisory and environmental groups, and concentrated media attention on the subject. Wasting food increases greenhouse gas emissions and contributes to climate change. The FAO concludes global food loss and waste is responsible for 8 percent of global man-made greenhouse gas emissions. The diagram below gives a simple illustration.

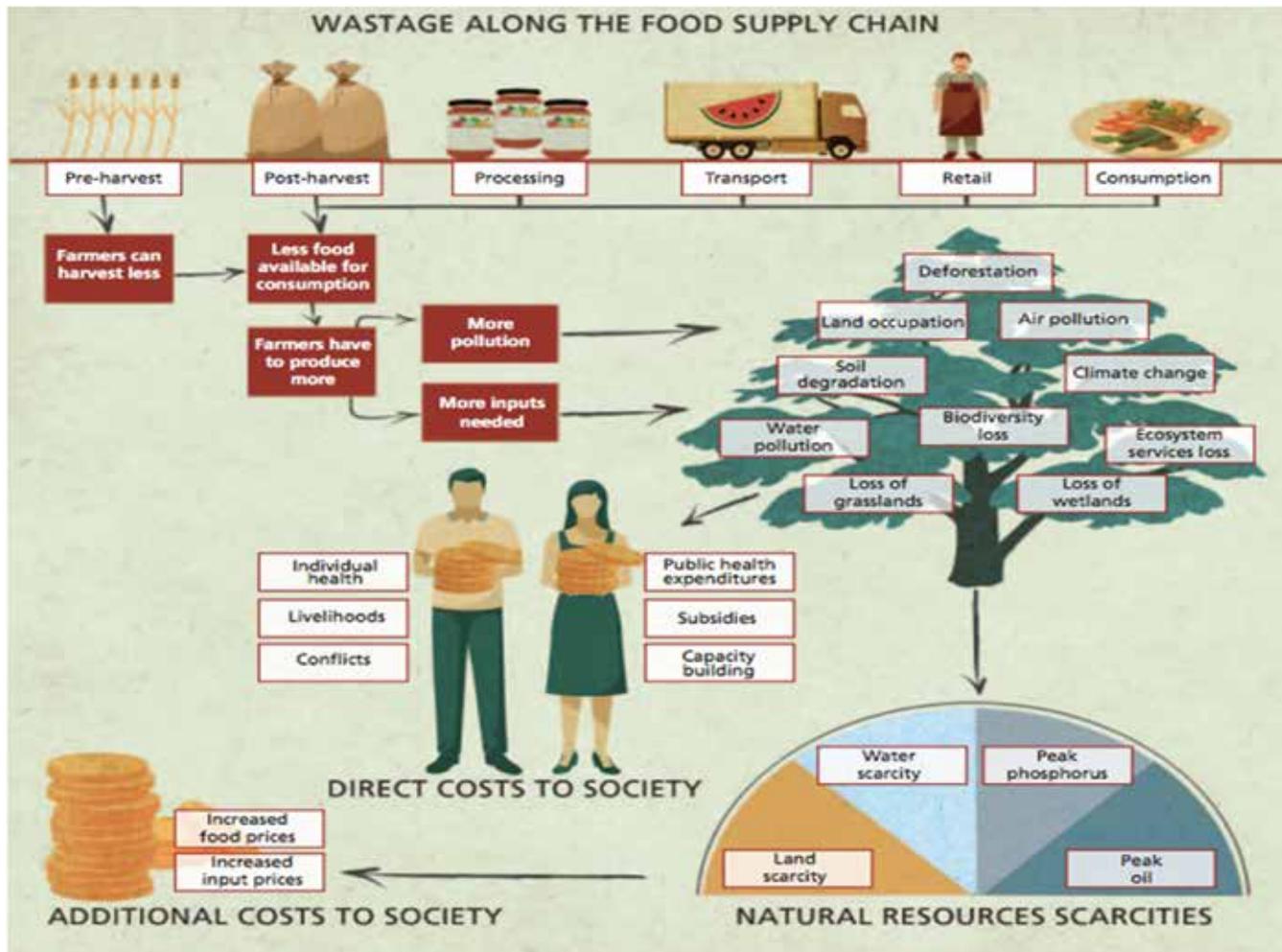


Figure 2: Food supply chain and societal & natural costs of food loss

2.4 Causes of Food Losses

Food is wasted throughout the food supply chain (FSC), from initial agricultural production down to final household consumption. In medium- and high-income countries food is to a high extent wasted, meaning that it is thrown away, even if it is still suitable for human consumption. Significant food loss and waste do, however, also occur earlier in the food supply chain. The causes of food waste and food loss differ in developing countries and in developed countries. In low-income countries food is mostly lost during the production-to-processing stages of the food supply chain. The following is relevant.

- (i) In industrialized countries food gets lost when production exceeds demand.

In order to ensure delivery of agreed quantities while anticipating unpredictable bad weather or pest attacks, farmers sometimes make production plans on the safe side, and end-up producing larger quantities than needed, even if conditions are “average”. In the case of having produced more than required, some surplus crops are sold to processors or as animal feed. However, this is often not financially profitable considering lower prices in these sectors compared to those from retailers.

Cooperation among farmers could reduce risk of overproduction by allowing surplus crops from one farm to solve a shortage of crops on another (Stuart, 2009).

- (ii) In developing countries and, sometimes, developed countries, food may be lost due to premature harvesting.

Poor farmers sometimes harvest crops too early due to food deficiency or the desperate need for cash during the second half of the agricultural season. In this way, the food incurs a loss in nutritional and economic value, and may get wasted if it is not suitable for consumption.

Small resource-poor farmers can be organized in groups to produce a variety of significant quantities of cash crops or animals. In this way they can receive credit from agricultural financial institutions or advance payments from buyers of the produce.
- (iii) High 'appearance quality standards' from supermarkets for fresh products lead to food loss

Some produce is rejected by supermarkets at the farm gate due to rigorous quality standards concerning weight, size, shape and appearance of crops. Therefore, large portions of crops never leave the farms. Even though some rejected crops are used as animal feed, the quality standards might divert food originally aimed for human consumption to other uses (Stuart, 2009).

Supermarkets seem convinced that consumers will not buy food which has the 'wrong' weight, size or appearance. Surveys do however show that consumers are willing to buy heterogeneous produce as long as the taste is not affected (Stuart, 2009). Consumers have the power to influence the quality standards. This could be done by questioning them and offering them a broader quality range of products in the retail stores.
- (iv) Poor storage facilities and lack of infrastructure cause postharvest food losses in developing countries.

Fresh products like fruits, vegetables, meat and fish straight from the farm or after the catch can be spoilt in hot climates due to lack of infrastructure for transportation, storage, cooling and markets (Rolle, 2006; Stuart, 2009). Governments should improve the infrastructure for roads, energy and markets. Subsequently, private sector investments can improve storage and cold chain facilities as well as transportation (Choudhury, 2006).
- (v) Unsafe food is not fit for human consumption and therefore is wasted.

Failure to comply with minimum food safety standards can lead to food losses and, in extreme cases, impact on the food security status of a country. A range of factors can lead to food being unsafe, such as naturally occurring toxins in food itself, contaminated water, unsafe use of pesticides, and veterinary drug residues. Poor and unhygienic handling and storage conditions, and lack of adequate temperature control, can also cause unsafe food.

Food chain operators should be skilled and knowledgeable in how to produce safe food. Foods need to be produced, handled and stored in accordance with food safety standards. This requires the application of good agricultural and good hygienic practices by all food chain operators to ensure that the final food protects the consumer.
- (vi) Disposing is cheaper than using or re-using' attitude in industrialized countries leads to food waste.

Industrialized food processing lines often carry out trimming to ensure the end product is in the right shape and size. Trimmings, in some cases, could be used for human consumption but are usually disposed of. Food is also lost during processing because of spoilage down the production line. Errors during processing lead to final products with the wrong weight, shape or appearance, or damaged packaging, without affecting the safety, taste or nutritional value of the food. In a standardized production line these products often end up being discarded (Stuart, 2009; SEPA, 2008). Both commercial and charity organizations could arrange for the collection and sale or use of discarded 'sub-standard' products that are still safe and of good taste and nutritional value (SEPA 2008).
- (vii) Lack of processing facilities causes high food losses in developing countries.

In many situations the food processing industry does not have the capacity to process and preserve fresh farm produce to be able to meet the demand. Part of the problem stems from the seasonality of production and the cost of investing in processing facilities that will not be used year-round. Governments should create better 'enabling environment' and investment climate, to stimulate the private sector to invest in the food industry and to work more closely with farmers to address supply issues.

- (viii) Large quantities on display and a wide range of products/ brands in supply lead to food waste in industrialized countries.

Retail stores need to order a variety of food types and brands from the same manufacturer to get beneficial prices. Consumers also expect a wide range of products to be available in stores. A wide range of products does, however, increase the likelihood of some of them reaching their "sell-by" date before being sold, and thereby wasted. When shopping, consumers expect store shelves to be well filled. Although certainly beneficial for sales statistics, continually replenished supplies mean that food products close to expiry are often ignored by consumers. This is particularly difficult for small retail stores (SEPA, 2008).

- (ix) Inadequate market systems cause high food losses in developing countries.

To minimize losses, the commodities produced by farmers need to reach the consumers in an efficient way. There are too few wholesale, supermarket and retail facilities providing suitable storage and sales conditions for food products. Wholesale and retail markets in developing countries are often small, overcrowded, unsanitary and lacking cooling equipment (Kader, 2005).

Marketing cooperatives are organizations providing a central point for assembling produce from small farmers and preparing commodities for transportation to markets and other distribution channels. The marketing cooperatives should be able to reduce food losses by increasing the efficiency of these activities. Although the development of wholesale and retail markets should preferably be done by the private sector, local governments and marketing cooperatives can be instrumental in establishing and improving market facilities (Kader, 2005).

- (x) Food wasted at consumer level is minimal in developing countries.

Poverty and limited household income make it unacceptable to waste food. A contributing factor is that consumers in developing countries generally buy smaller amounts of food products at the time, often just enough for meals on the day of purchase.

- (xi) Abundance and consumer attitudes lead to high food waste in industrialized countries.

Perhaps one of the most important reasons for food waste at the consumption level in rich countries is that people simply can afford to waste food. The amount of available food per person in retail stores and restaurants has increased during the last decades in both the USA and the EU. A lot of restaurants serve buffets at fixed prices, which encourages people to fill their plates with more food than they can actually eat. Retail stores offer large packages and "getting one for free" bargains. Likewise, food manufacturers produce oversized. The nature and principal causes of post-harvest losses can be seen for the following Table (Anonymous, 2019).

Table 2.2 Nature and causes of PHLs of produces

Nature	Direct causes	Indirect causes
In weight	Premature harvest	Inadequate:
	Poor maturation	- capital
	Poor threshing	- professionalism
	Insufficient drying	- equipment
	Insufficient cleaning	- pesticides
In quality	Bird attack	- packaging
	Rodent attack	- transport
	Insect attack	- organization
	Micro-organism attack	Constraints:
	Biochemical change	-social
Economic	Leakage and waste	-economic
	Wrong moisture content for storage	-political
	Inadequate storage and transport techniques	

2.5 Stages of Food Losses

It follows that if the question of post-harvest losses is to be tackled empirically, it is above all necessary to know, in each situation, the nature and number of manipulations the product undergoes, as well as the causes and incidence of losses during each stage in the process. The following figure depicts the matters of causes of food wastage.

(i) Production

Food waste can occur at most stages of the food industry and in significant amounts. In subsistence agriculture, the amounts of food waste are unknown, but are likely to be insignificant by comparison, due to the limited stages at which waste can occur, and given that food is grown for projected need as opposed to a global marketplace demand. Nevertheless, on-farm losses in storage in developing countries, particularly in African countries, can be high although the exact nature of such losses is much debated.

(ii) Food processing

Food loss continues in the post-harvest stage, but the amounts of post-harvest loss involved are relatively unknown and difficult to estimate. Regardless, the variety of factors that contribute to food waste, both biological/environmental and socio-economical, would limit the usefulness and reliability of general figures. In storage, considerable quantitative losses can be attributed to pests and micro-organisms. This is a particular problem for countries that experience a combination of heat (around 30 °C) and ambient humidity (between 70 and 90 per cent), as such conditions encourage the reproduction of insect pests and micro-organisms. Losses in the nutritional value, caloric value and edibility of crops, by extremes of temperature, humidity or the action of micro-organisms, also account for food waste. Further losses are generated in the handling of food and by shrinkage in weight or volume.

(iii) Retail

Packaging protects food from damage during its transportation from farms and factories via warehouses to retailing, as well as preserving its freshness upon arrival. Although it avoids considerable food loss, packaging can compromise efforts to reduce food loss in other ways, such as by contaminating loss that could be used for animal feedstock.

Retail stores throw away large quantities of food. Usually, this consists of items that have reached either their best before, sell-by or use-by dates. Food that has passed the best before, and sell-by date, and even some food that passed the use-by date is still edible at the time of disposal, but stores have widely varying policies to handle the excess food. Some stores put effort into preventing access to poor or homeless people, while others work with charitable organizations to distribute food. Retailers also contribute to waste as a result of their contractual arrangements with suppliers. Failure to supply agreed quantities renders farmers or processors liable to have their contracts cancelled. As a consequence, they plan to produce more than actually required to meet the contract, to have a margin of error. Surplus production is often simply disposed of..

(iv) Consumption

Consumers are directly and indirectly responsible for wasting a lot of food, which could for a large part be avoided if they were willing to accept sub-optimal food (SOF) that deviates in sensory characteristics (odd shapes, discolorations) or has a best-before date that is approaching or has passed, but is still perfectly fine to eat.

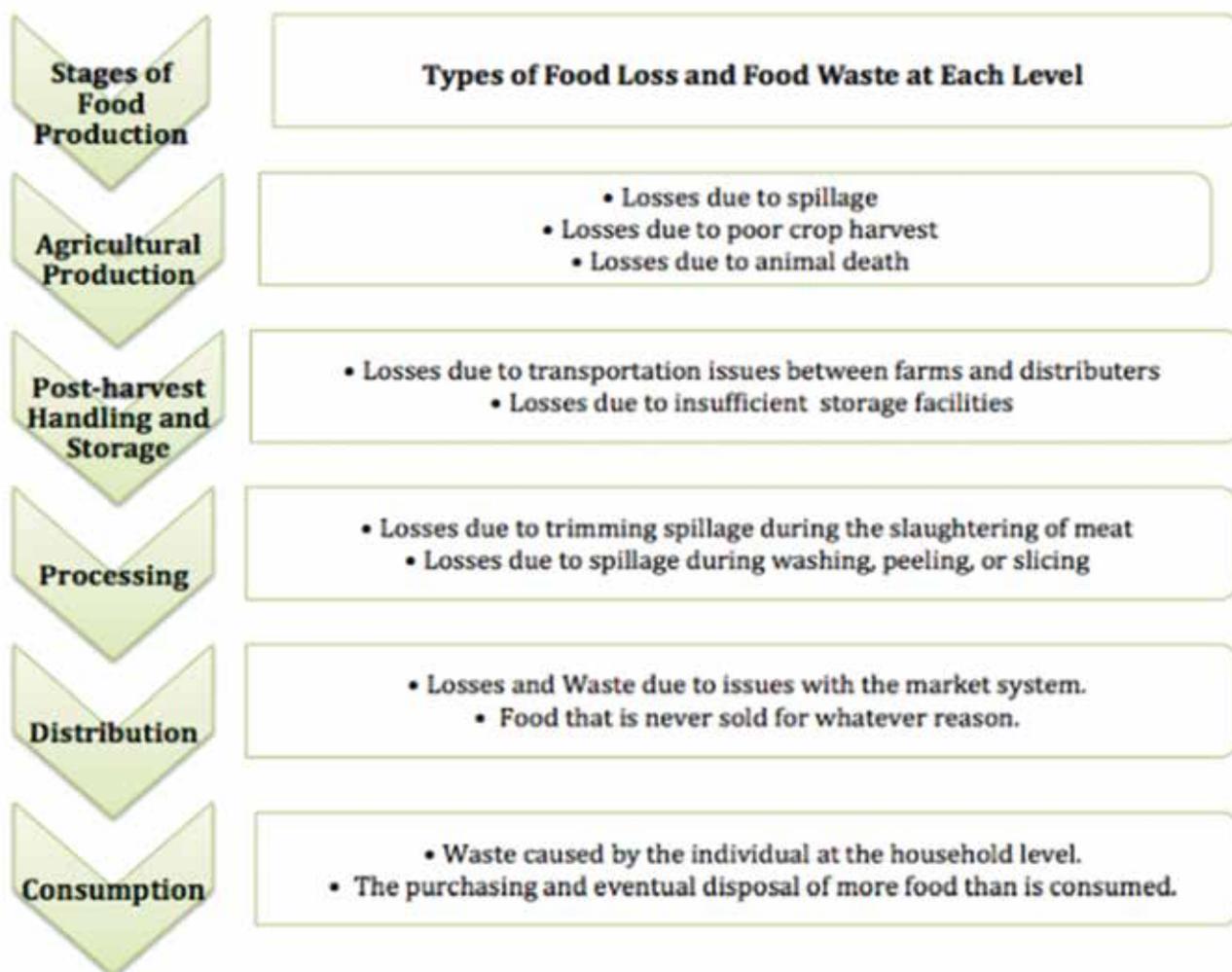


Figure 3: Causes of Food Loss at Different Stages

The global postharvest losses at food supply chain may be seen below:

- (i) Harvesting – 4-8%
- (ii) Farm storage-2.5%
- (iii) Transport to homestead – 2-4%
- (iv) Drying – 1-2%
- (v) Market storage – 2-4%
- (vi) Cumulative loss from production – 10-23%
- (vii) Threshing/shelling – 1-3%

Food loss and food waste occur at each level of the food production process which can be seen from the above diagram (Anonymous, 2019).

2.6 Developing Countries - Causes of Food Loss and Food Waste

- (i) Poor farmers harvest crops too early in response to a lack of food and money.
- (ii) Food harvested too early cause loses in both economic and nutritional value.
- (iii) Minimal farming technology such as plows, tractors, and pesticides.
- (iv) Inadequate market systems.
- (v) Markets are often small, overcrowded, unsanitary, and lack proper cooling equipment.
- (vi) Fresh produce, meat, and fish spoil in hot climates due to the lack of proper transportation.

2.7 Developed Countries - Causes of Food Loss and Food Waste

- (i) Farmers produce excess food out of anticipation of poor weather or pest attacks.
- (ii) Supermarkets have appearance quality standards.
- (iii) Edible food may be rejected by supermarkets due to crops not being favorable in terms of weight, size, or shape.
- (iv) Supermarkets display large quantities of products that reach their sell-by date before being sold.
- (v) Bulk sized packaging in supermarkets.
- (vi) Large portion meals in restaurants.
- (vii) The attitude that disposing is cheaper than using or re-using
- (viii) Households buy more food than needed.



Picture: Huge heap in packs causing damage to tomatoes. (Anonymous, 2019a)

Food waste happens all over the world, but in different ways. In developing countries, the majority of food losses happen post-harvest and during processing, due to problems like inadequate storage and refrigeration. But, in industrialized countries—like those in North America, Europe, and industrialized Asia—almost half of all food losses happen in grocery stores, restaurants, and our own homes. In Europe and North America, per capita waste by consumers is around 209-253 lbs. (95-115 kg) each year. That averages to over ½ lb. of food wasted per person, per day.

2.8 Environmental Impacts of Food Loss

When edible items are discarded, it's not just food that is wasted. Consider all the resources required to bring food from the farm to consumer's table: water for irrigation, land for planting, and fuel for powering harvest and transport vehicles. When a bunch of bananas falls off a truck or restaurant owners fill their rubbish bins with uneaten meals, all those resources are essentially wasted right along with the food (Depta, 2018).

Every which way you look at it, food waste is a major culprit in destroying our planet. The urgent need to address climate change and make food systems more environmentally sustainable has pushed the issue of food losses and waste to the forefront. Food losses and waste have negative environmental impacts. When food is squandered, so too are the water, soil, biodiversity and other natural resources and inputs that were used to produce it and move it through the supply chain. These impacts can be expressed as a 'food loss and waste footprint' on the environment.

Attempts have been made to quantify the global environmental impacts of food losses and waste, especially with regards to greenhouse gas emissions. Food production is responsible for a large share of GHG emissions, reducing food losses and waste contributes to climate change mitigation. At the same time, because climate change threatens food production in many food insecure areas, reducing food losses and waste can be an important part of climate change adaptation strategies (Bellú, 2016).By

one estimate, food losses and waste generate every year more than 3.3 giga tons of carbon dioxide equivalent (FAO, 2013), equal to the combined annual carbon dioxide emissions of Japan and the Russian Federation.

Food waste that ends up in landfills produces a large amount of methane – a more powerful greenhouse gas than even CO₂. For the uninitiated, excess amounts of greenhouse gases such as methane, CO₂ and chlorofluorocarbons absorb infrared radiation and heat up the earth's atmosphere, causing global warming and climate change. Improving the efficiency of food systems, so that less food is lost and wasted, has been identified as an important way of reducing GHG emissions from the food and agriculture sector without compromising food security. The redesign of food supply chains and the introduction of sustainable technologies and improved retail models, which are needed to reduce food losses and waste, may also make food systems more energy-efficient and indirectly reduce emissions. More efficient food systems also recycle resources more effectively and require less transport and storage. All of these benefits lead to savings in natural capital, reduced consumption of resources and lower GHG emissions (FAO, 2017).

Twenty-eight per cent of the world's agricultural area is used to produce food that is ultimately lost or wasted each year. Not only does that result in unnecessary degradation of land, but clearing land for agricultural purposes is also a cause of deforestation, which eliminates wildlife habitats and wipes out greenhouse-gas-absorbing trees. If you look at land usage, around 1.4 billion hectares of land, which is roughly one-third the world's total agricultural land area, is used to grow food that is wasted.

Studies have also estimated that the agri-food sector currently accounts for around 30 percent of the world's total energy consumption, and that the energy embedded in global food losses is 38 percent of the total final energy consumed by the whole food supply chain. This means that more than 10 percent of the world's total energy consumption is for food that is lost and wasted.

Furthermore, fresh water is one of Earth's most precious resources, and 70 per cent of it is used for agricultural purposes, including crop irrigation and drinking water for livestock. Did we know the production of just one apple requires an average of 125 liters of water? With agriculture accounting for 70 percent of the water used throughout the world, food waste also represents a great waste of freshwater and ground water resources. It is said that a volume of water roughly three times the volume of Lake Geneva is used just to produce food that is not eaten. By throwing out one kilogram of beef, you are essentially wasting 50,000 liters of water that were used to produce that meat. In the same way, nearly 1000 liters of water are wasted when you pour one glass of milk down the drain and throwing away a bruised apple is akin to pouring 125 liters of water down the drain.

If we look at land usage, around 1.4 billion hectares of land, which is roughly one-third the world's total agricultural land area, is used to grow food that is wasted. Millions of gallons of oil are also wasted every year to produce food that is not eaten. And all this does not even take into account the negative impacts on biodiversity due to activities like mono-cropping and converting wild lands into agricultural areas.



Nature and Extent of Postharvest Loss in CIRDAP Member Countries (CMCs)



Nature and Extent of Postharvest Loss in CIRDAP Member Countries (CMCs)

Long-term growth prospects for Asia-Pacific are impacted by demographics, slowing productivity growth, and the rise of the digital economy. One important challenge is population aging, as many economies in the region face the risk of “growing old before they grow rich,” and the adverse effect of aging on growth and fiscal positions could be substantial. A second challenge is slowing productivity growth. Finally, the global economy is becoming increasingly digitalized, and while some recent advances could be truly transformative, they also bring challenges, including those related to the future of work. Asia is embracing the digital revolution, albeit with significant heterogeneity across the region (IFM, 2018).

Asia's position in the global food market tilts heavily towards demand due to its huge population and limited agricultural resources. With only one-fifth of the world's agricultural land, the region hosts more than half of the global population. Asia has achieved significant production improvements over the last 50 years but produces lower yields compared to most other regions, with depleting resources including water, deteriorating soil quality, inadequate logistics and inefficient farming practices and land usage. These issues are beginning to be challenged and addressed through market-oriented approaches and corporate farming to satisfy a growing population featuring rising income levels, urbanization, demand for higher food quality and environmental concerns (Chew and Soccio, 2016).

As often observed, during the initial stages of economic growth an improvement in average income leads to an increase in cereal consumption. However, as income continues to rise, food consumption gradually shifts from staples to protein and other high value food items like dairy, fruit and vegetables. With economic prosperity likely to continue to improve in the region, we can expect dramatic shifts in both the shape and the composition of the Asian food basket. In emerging Asia as a whole, between 1991 and 2011, the share of fruit, vegetables, meat and fish in the consumption basket grew faster than the share of staple foods. Total demand for grains is on the rise, as the increasing share of meat intake is leading to strong growth in demand for animal feed.

Furthermore, as the modern trade share of overall groceries increases, consumption will shift from unprocessed and unbranded to branded and packaged food. This presents an interesting dichotomy in that whilst overall cereal consumption growth in Asia will mirror steady growth in population, the branded cereals category may continue to see robust growth for several years. For instance, whilst overall rice consumption in India per capita is lagging behind population growth, the organised, branded rice market is growing at 15% per annum. The Asian agricultural development may be characterized as:

- (i) The Asia region is a decisive component in the global food chain, accounting for 19% of total global food and agriculture exports and 31% of total food and agriculture imports
- (ii) Asia's large and growing population, coupled with rising incomes and a burgeoning middle class, will continue to drive demand for food & agricultural commodities and resources
- (iii) On the other hand, Asia cannot produce enough to support itself. Limited arable land, inadequate water and poor resource management, low farm yields, environmental and soil degradation and infrastructure inadequacy are limiting production. Consequently, Asia and especially China's need for

imports and investment locally and abroad is likely to increase.

- (iv) Asia agribusiness and food & agriculture companies are likely to grow in size and scope to meet the increasing demand, national policies, rising organizational capabilities, and integration and consolidation throughout the value and supply chains (Chew and Soccio, 2016).

Apart from production and production factors, the postharvest matters of agricultural crops (especially cereals, fruits and vegetables) are also very crucial. Because, inefficiencies in the food supply chain and marketing systems in Asian and other developing nations are bearing a threat to food and nutrition security.

Considering the issues raised, this chapter overviewed the related matters to nature and extent of food loss; quantity of production in postharvest losses in CMCs; major causes of postharvest losses; effects and challenges of postharvest losses and their possible solutions. Some of the crucial issues for further discussions are mentioned on the following sections.

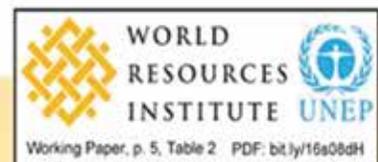
3.1 Nature and extent of food loss in supply chain and related issues

Food waste typically, but not exclusively, occurs at the retail and consumption stages in the food value chain and is the result of negligence or a conscious decision to throw food away. Food loss and waste (FAO, 2013) apply to food products in the value chain starting from the moment that:

- (i) Crops are ripe in the field, plantation, or orchard;
- (ii) Animals are on the farm—in the field, sty, pen, shed, or coop—ready for slaughter;
- (iii) Milk has been drawn from the udder;
- (iv) Aquaculture fish are mature in the pond; and
- (v) Wild fish have been caught in the net.

Table 2.3 Food loss and waste along the value chain (Lipinski et al., 2013)

Production	Handling and Storage	Processing and Packaging	Distribution and Market	Consumption
DEFINITION				
During or immediately after harvesting on the farm	After produce leaves the farm for handling, storage, and transport	During industrial or domestic processing and/or packaging	During distribution to markets, including losses at wholesale and retail markets	Losses in the home or business of the consumer, including restaurants/caterers
INCLUDES				
Fruits bruised during picking or threshing	Edible food eaten by pests	Milk spilled during pasteurization and processing (e.g., cheese)	Edible produce sorted out due to quality	Edible products sorted out due to quality
Crops sorted out post-harvest for not meeting quality standards	Edible produce degraded by fungus or disease	Edible fruit or grains sorted out as not suitable for processing	Edible products expired before being purchased	Food purchased but not eaten
Crops left behind in fields due to poor mechanical harvesting or sharp drops in prices	Livestock death during transport to slaughter or not accepted for slaughter	Livestock trimming during slaughtering and industrial processing	Edible products spilled or damaged in market	Food cooked but not eaten
Fish discarded during fishing operations	Fish that are spilled or degraded after landing	Fish spilled or damaged during canning/smoking		



The value chain ends at the moment food products are consumed by people, discarded, or otherwise removed from the food chain intended for direct human consumption. Therefore, food that was originally meant for human consumption but is removed from the food chain is considered food loss or waste, even if it is then used as animal feed or bio-energy. Food loss and waste can occur at each stage of the food value chain (Table 2.3).

Some examples of how they can occur at each stage are (Lipinski et al., 2013);

- (i) During production or harvest in the form of grain left behind by poor harvesting equipment, discarded fish, and fruit not harvested or discarded because they fail to meet quality standards or are uneconomical to harvest.
- (ii) During handling and storage in the form of food degraded by pests, fungus, and disease.
- (iii) During distribution and marketing in the form of edible food discarded because it is non-compliant with aesthetic quality standards or is not sold before “best before” and “use-by” dates.
- (iv) During consumption in the form of food purchased by consumers, restaurants, and caterers but not eaten. The diagram in Table 2.3 from the World Resource Institute reflects the flow of Food Loss and Waste along the Value Chain.

It is considered that, food loss and waste do not include:

- (i) By-products—such as bones, organs, skins, seeds, peels, hulls, and bran—that could be considered unavoidable food waste because in specific supply chains they are not intended for human consumption and are discarded or used in non-food products;
- (ii) Surplus food that is redirected to food banks and subsequently eaten by people;
- (iii) Food grown intentionally for feed, seed, or industrial use; and
- (iv) Overconsumption beyond recommended caloric needs.

The level of food losses differ from one stage of the food supply chain to another, depending on crop type, level of economic development, as well as social and cultural practices in a region. In the case of cereals, fruits and vegetables, losses at harvest and during sorting and grading dominate in industrialized regions, probably mostly due to discarding during grading to meet quality standards set by retailers (FAO, 2011). In developing regions, while losses at harvest and during sorting and grading are also high, losses during processing (14% – 21%) are much higher than those in developed regions (< 2%). The distinct difference highlights the need to improve processing technologies for perishable products like cereals, fruits and vegetables in developing regions. The food industry can make a substantial contribution in this area by developing and disseminating low-cost and effective techniques such as drying (Rezaei and Liu, 2017).

(100 % = 1.5 quadrillion kcal)



Data source: [Reducing food loss and waste, 2013](#).
 Note: Number does not sum to 100 due to rounding.

Figure 4: Share of total food loss and waste by stage in the value chain (2009)

The above figure (Figure 4) shows the percentages of total food loss and waste in developing and developed countries in different levels from production to consumption level including other 3 levels. For production level the total food loss and waste is 14% in developing countries and 10% in developed countries. By this way all the loss percentages are depicted in above bar diagram to show the loss and waste by stages in the value chain.

3.2 Quantity of production and post-harvest losses in CMCs

Growing populations across the Asia-Pacific region continue to create demand for fresh produce and processed horticultural products. Meeting these requirements as well as those of export markets necessitates assuring quality and safety in both domestic and export supply chains. Capacities must therefore be developed across the region in order to respond to consumer and market demand and to avert the risk of large numbers of small farmers becoming marginalized. At the same time, Governments in the region must develop a vision for the development of the postharvest sector and facilitate activities within the sector in order to realize that vision (APO, 2006).

Food security, both in terms of availability and access to food, poses a challenge to rapidly growing populations, in environments of dwindling land and water resources. The horticultural sector has established its credibility for improving land use, and generating employment and nutritional security. Horticulture, which includes the production of fruits, vegetables, flowers, spices, medicinal and aromatic plants and plantation crops has emerged as a major economic activity in Asia and Pacific. The Asia-Pacific region contributes to more than 50% of the world' s acreage under fruits and vegetables and produces a diversity of fruits such as apples, bananas, oranges, grapes and mangoes in addition to tropical and sub-tropical fruits such as pineapples, papayas, guavas, litchi and passion fruit (Choudhury, 2006).

Asia and the Pacific region have witnessed rapid growth in horticultural development. Changes in dietary habits owing to increasing incomes continue to accelerate demand for horticultural produce in the region. This increased demand must be met in an environment of shrinking land and water resources. At the same time, development in science and technology could provide an opportunity for intensifying the production of horticultural produce.

According to FAO (2004), in developing countries postharvest losses of cereal, fruits and vegetables are more serious than those in developed countries. In most developing countries the number of scientists concerned with postharvest handling research is significantly lower than those involved in production research. The handling procedures used in technologically advanced countries to reduce post-harvest losses are not fully recognized in developing countries.

It further suggests that in developing countries, for perishable crops like fruits and vegetables, storage, packaging, transporting and handling technologies are practically non-existent, hence considerable amount of produce are lost. Tyler and Gilman, (1979) outlines the multiple effects of postharvest loss as going beyond the loss of the actual crop to include loss in the environment, resources, labor needed to produce the crop and livelihood of the individuals involved in the production process. Post-harvest loss tends to prevent adequate supply of and accessibility to fresh agricultural produce, thereby causing an increase in the price of such produce at certain period in the year and leading to a glut at another time.

However, the cases of CMCs are presented in the following sections to grasp ideas on various issues of PHLs in CMCs. At the beginning, a scenario of horticultural production along with some cereals is presented in the following Table.

Table 2.4: Average Production during 2000-2009 and 2010-2017 in CMCs

Country	Food	2000-2009 Average production (ton)	2010-2017 Average production (ton)	Average production (ton)
Afghanistan	Cereals	46527330		5815916
	Vegetables	1108694		964429.125
	Fruits	1059990.6		1747425.375
Bangladesh	Cereals	42136351		53740468.5
	Vegetables	2378721.5		240637489
	Fruits	3230050		4198724
Fiji	Cereals	14280		6312.4
	Vegetables	24351.2		26488.5
	Fruits	21595.4		22680.13
India	Cereals	217692638		291962602
	Vegetables	78430834.9		116237468
	Fruits	54547737		84198937
Indonesia	Cereals	67258370		92945508
	Vegetables	7552333		10209002
	Fruits	14392389		18375919
Iran	Cereals	18925605.6		18254612
	Vegetables	10539727		14115014
	Fruits	16875601		18667231

Lao PDR	Cereals	3231968	3887058
	Vegetables	737597	1453618
	Fruits	103407	101934
Malaysia	Cereals	2329661.9	2624776
	Vegetables	520701.8	1087904
	Fruits	1285144.4	1210741
Myanmar	Cereals	27758176.1	29412482.1
	Vegetables	4032038.2	4852777.63
	Fruits	2324973.38	2397301.5
Nepal	Cereals	7555196	8953308
	Vegetables	2394468	3510988
	Fruits	1021081	1745720
Pakistan	Cereals	31997940	40043887
	Vegetables	4599425.2	4819927
	Fruits	6317722	6904933
Philippine	Cereals	22343420.6	25188727.3
	Vegetables	5339172	6269330
	Fruits	16336206	17948720
Sri Lanka	Cereals	3197840	3197840
	Vegetables	623773.9	861811.1
	Fruits	771637.1	857670.6
Thailand	Cereals	34450261	38843132
	Vegetables	3386431	2869049
	Fruits	11022233	10898201
Vietnam	Cereals	38926011	48323544
	Vegetables	9180096	12637202
	Fruits	7511362	8248133

Source: FAOSTAT (2000-2017)

Globally, about 24 percent of all the calories produced for human consumption do not end up reaching human mouths, according to WRI analysis (Jennison, 2014). Actually, a company or a country cannot cut its food loss and waste if it does not know the total amount of food being wasted at the outset. So, it is imperative to know details of the losses at different stages of food chain. Again, the losses varies from region to region according to their socio-economic growth and development of which something can be predicted from the following figure.

Food loss and food waste vary in various stages of the food supply chain. Similarly, the rate varies also due to the variation of the food product itself. In one estimate, Korosec (2012) showed that Americans are throwing away 40 percent of food in the U.S., the equivalent of \$165 billion in uneaten food each year, according to the NRDC analysis. Food waste has jumped 50 percent since the 1970s and is now the single largest component of solid waste in U.S. landfills. The study estimated the varied loss of various food products at different stages of food supply chain as shown in the Table below.

Table 2.5 Current Food Losses of cereal crops, vegetables and fruits in different stages of supply chain

Food item	Post-harvest losses (Percentage) in different stages of supply Chain
Cereal crops	Production: 2
	Post harvesting handling and storage: 2
	Processing and packaging: 10
	Distribution: 2
	Consumer: 27
Fruits and Vegetables	Production: 20
	Post harvesting handling and storage: 3
	Processing and packaging: 1
	Distribution: 12
	Consumer: 25

In the developing world, lack of infrastructure and associated technical and managerial skills in food production and post-harvest processing have been identified as key drivers in the creation of food waste, both now and over the near future (WFP 2009). This situation contrasts with that in developed countries where interviewees forecast the majority of food waste continuing to be produced post consumer, driven by the low price of food relative to disposable income, consumers' high expectations of food cosmetic standards and the increasing disconnection between consumers and how food is produced. Similarly, the increasing urbanization within transitioning countries will potentially disconnect those populations from how food is grown, which is likely to further increase food waste generation.

Across the globe, resource and commodity limitations, in part as a result of an increasing population but also owing to impacts of climate change, were viewed as being likely to increase the economic value of food, potentially driving more efficient processes that could lead to food waste reduction. Industrialized FSCs will continue to develop in response to these wider challenges by the development of shared logistics (e.g. collaborative warehousing), identification and labeling of products (use of barcodes and RFID tags) and better demand forecasting (Global Commerce Initiative 2008), and domestic kitchen technologies (smart fridges, cookers, online meal planning and recipe resources) may make it easier for consumers to manage their food better.

3.3 Cost of Post-Harvest Losses

Like loss assessment, calculation or assessment of costs and cost prices entails considerable difficulties, if not uncertainties, all the relevant factors are to be taken into account. It is particularly important to be clear as to whether the "rational" economy of an industrialized country or that of a developing country is involved. Even then, such figures are always of relative value and are dependent on a socio-economic framework that must never be forgotten. These difficulties are certainly one of the main reasons why economic data are poorly developed in works on post-harvest systems and losses. Food losses and waste amount to roughly US\$ 680 billion in industrialized countries and US\$ 310 billion in developing countries. The amount of food lost or wasted every year is equivalent to more than half of the world's annual cereals crop (2.3 billion tons in 2009/2010).

3.4 Types of Food Loss; from Harvesting to Market

In developing countries, wastage and food losses occur mainly at the early stages of the food value chain and can be linked to financial, management, and technical constraints in harvesting techniques as well as storage and cooling equipment. Strengthening the supply chain through the direct support of farmers and investments in infrastructure, transport, as well as in the development of the food and packaging industry can help reduce the amount of food wastes and losses. In middle- and high-income countries, food is wasted and lost mainly at later stages of the supply chain. There is no coordination between entities in the supply chain as a factor contributing to post-harvest losses. Farmers' agreements can help to increase the level of this coordination.

Post-harvest losses occur mainly due to corruption and meager infrastructure in the developing world. Pre-harvest losses are another major factor in the developing world, as a result of insufficient investment in bio security practices (Anonymous. 2011). As to where the food is disappearing: in developing nations, 40 per cent of losses take place during the post-harvest and processing phases, while 25 percent of losses happen during the pre-harvest phase; in industrialised countries, more than 40 per cent of losses occur at the retail and consumer level.

Postharvest losses vary greatly among commodities and production areas and seasons. As a product moves in the postharvest chain, PHLs may occur from a number of causes, such as improper handling or bio deterioration by microorganisms, insects, rodents or birds. An important factor in developed countries is that a large amount of the food produced is not eaten but discarded, for reasons such as it was left on the plate after a meal or it passed its expiry date. In contrast, failure to consume available food in Less Developed Countries (LDCs) is not a reported concern; instead the low-quality food remaining in markets at the end of the day is sustenance for the very poor. The issue in LDCs is inefficient postharvest agricultural systems that lead to a loss of food that people would otherwise eat, sell or barter to improve their livelihoods (Hodges et al., 2010). There are internal and external factors contributing to postharvest loss. But it should be kept in mind that there is a huge dearth of quantitative data regarding PHLs of various cereals, fruits and vegetables. In spite of these limitations, the various types of PHLs in different CMCs are summarized below. Here data from 2000 to till date has been used.

Table 2.6 Current food losses of cereal, vegetables and fruits in different stages of supply chain from harvest to market in CMCs

A. South Asia						
Serial No	Food item	Post-harvest losses in different stages of supply Chain (Percentages)				
Afghanistan	Cereal crops	Wheat: 15% Maize: 15% Barley: 15% Rice: 7% (Data of the losses from different stages is not available in the literature) (Hector, 2005)				
	Fruits	Problem in sorting, grading and packaging of apples, there are significant losses (11.2 %) that the farmers are encountered during sorting, grading and packaging 14 % (as an average) losses in terms of quality (flavor, color and shape) and weight losses arise from the improper storage of apples (Masood, 2011)				
Bangladesh	Cereal crops	PHLs of rice at different stages- Harvesting: 1.06-6.50% Threshing: 1.65-2.00% Storing: 3.05-7.50% Transporting:0.63-6.00% Wheat: 8-10% and Major pulses: 18-25% (Amiruzzaman, 2001)				
	Fruits	Total loss: 50 % (Hossain, 1993)				
	Vegetables	Cucumber 27.1% Red amaranth 28.6% Brinjal 29.4% Okra 32.3% Tomato 32.9% Cauliflower 34.4% Source: Hassan et al., 2010 Potato- 20-26% Source: (Bhuiyan et al. 2012)				
India	Cereal crops	Post-harvest losses during different operation for paddy at producers' level <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th>Stages of losses</th> <th>Percentage Loss</th> </tr> </thead> <tbody> <tr> <td>Field to threshing floor</td> <td>0.79 %</td> </tr> </tbody> </table>	Stages of losses	Percentage Loss	Field to threshing floor	0.79 %
Stages of losses	Percentage Loss					
Field to threshing floor	0.79 %					

		<p>Threshing 0.89 % Winnowing 0.48 % Transport from threshing floor to Storage 0.16 % Storage at producers level 0.04 % Total losses at producers level 2.72 %</p> <p>Different reasons may cause post harvest losses of wheat</p> <p>Stages of losses Percentage loss</p> <p>Threshing 1.0 Transport 0.5 Processing - Rodents 2.50 Birds 0.5 Insect 3.0 Moisture 0.5 Total : 8.0</p> <p><i>Rashad (2013)</i></p>
	Vegetables	<p>Vegetables with their total PHLs (%)</p> <p>Tomato 23.19 Potato 16.88 Onion 13.77 French bean 16.73 Cauliflower 13.43 Cabbage 8.65 Pea 16.37 Chilly 16.75 Radish 6.52 Capsicum 10.43 Okra 15.63 Brinjal 16.81</p> <p><i>Rashad (2013)</i></p>
	Fruits	<p>Physical loss (% sorted out and discarded) of fruits in farm</p> <p>Mango – 6.5% Litchi - 9.8% Cucurbit – 12.7%</p> <p>Physical loss (% sorted out and discarded) of fruits for wholesale market</p> <p>Mango – 7.9% Litchi - 11.4% Cucurbit – 3.8%</p> <p>Physical loss (% sorted out and discarded) for Retail market</p> <p>Mango – 7.1% Litchi - 10.1% Cucurbit – 9.2%</p> <p><i>(PEF White Paper 15-02, 2015)</i></p>
Nepal	Cereal crops	<p>Loss of some cereals -</p> <p>Field and storage for wheat 27% Maize grain or seed loss in storage range was 10-20% Maize loss in field and storage 27% Cereals was about 15-20%. Loss in storage was 8% in Mountain Loss in storage was 7.4% in Hills Loss in storage was 13% Terai of Nepal. <i>(Ghanashyam et al., 2015)</i></p>
	Vegetables	<p>Total PHLs (%) of some vegetables:</p> <p>Cauliflower – 47% Cabbage – 43% Radish – 10.5% Tomato – 10% <i>(PEF White Paper 15-02, 2015)</i></p>

	Fruits	<p>Fruits and vegetables loss (%) due to:</p> <p>Rotting – 51%</p> <p>Mechanical damage – 22%</p> <p>Physiological loss – 27%</p> <p>Loss of some fruits:</p> <p>Junar (sweet orange): 29% loss</p> <p>Apple:12% - 20% loss (Devkota et al.,2014)</p>
Pakistan	Cereals	<p>Post-harvest losses in</p> <p>Durables(cereals and pulses) – 10%</p> <p>Perishables (fruits and vegetables) – 22%</p> <p>The cost of annual harvest and post-harvest losses is estimated around Rs. 228.8 billion for gains, fruits and vegetables only. The losses happened at harvest, threshing, storage and transportation stages. It is estimated that available storage facilities are three time less than the requirements (National Food Security Policy, 2017)</p> <p>Rice PHLs are in Pakistan up to 30%. (Khan, 2010).</p> <p>Post-harvest losses in wheat is 10 percent</p> <p>Insects and mites are also partially responsible in post-harvest loss in food grain, 40-70 percent losses from total loss are due to these factors (Abbas et al., 2013).</p>
	Vegetables	<p>Losses of vegetables:</p> <p>Tomato- 20%</p> <p>Potato-12%</p> <p>Onion-9%</p> <p>Tomato loss for</p> <p>Packing material was 25%</p> <p>Transportation system was 10%</p> <p>Means of distribution was 5 %, exceeding post-harvest losses up to 30% (Haque and Khan, 2010).</p> <p>About 30% tomatoes are wasted daily in the markets of Lahore district due to transportation (Haque and Khan, 2010).</p> <p>Post-harvest losses of tomato crop in Peshawar valley were estimated 20% of the total production (Jan,2007)</p>
	Fruits	<p>PHLs of fruits -</p> <p>Kinnow-45%</p> <p>Mangoes- 25-40%</p> <p>Peach -23 %</p> <p>Leghari (2001) reported that in Pakistan, the magnitude of post-harvest losses of vegetables and fruits were about 35 percent.</p> <p>Losses at farm, market and consumption level and reported as 38.6, 35.9 and 25.5 percent of the total losses and total post-harvest losses were 31 percent of the total production (Bari, 2004).</p> <p>In these losses 15-20% are at the time of management harvested crop, 5-8 percent at harvesting and 10-12 percent loss in vegetable and fruits when it transport. Agro-climatic conditions in Pakistan vary from tropical region to temperate regions, where 40 different types of vegetables, 20 types of fruits are produced in Pakistan.</p> <p>In Pakistan the total fruits and vegetables are produced nearly 13.674 million tons, it is expected that 30 – 40 percent goes to waste. More than 50 percent in mulberry, apricots, cherry, while in almond and walnuts is 6 percent. In horticultural crops has 40 percent low price as compared to the world average price due to the low standard of post harvest management (Abbas et al., 2013).</p>

Sri Lanka	Cereal crops	n/a
	Vegetables	Tomato - 54% cumulative (Rupasinge et al., 1991)
	Fruits	According to statistics it is estimated about 270000 tonnes of fruits are lost. Banana is the most popular and most cultivated fruit in SL, but the post-harvest losses are estimated as- Banana nearly 30%, Papaya 46%, Pineapples 18%, Avocado 40% Mango 41% (Kodippili, 2016) The average postharvest loss during transportation was 8.5% ranging between 5% - 10%. Bananas: 20% from farm gate to retailer Banana transportation loss- 8.5% (Wasala et al., 2014)

B. South East Asia

Indonesia	Cereal crops	Rice postharvest losses (%) in 2012 Harvesting 0.53 Threshing 0.83 Drying 6.09 Milling 2.98 (Indonesian Center for Agricultural Postharvest Research and Development, 2017) PHL of Maize in Central Lampung District Postharvest operation Harvesting- 0.1% Sun drying 2-5% Mechanical drying 0.1% Shelling at high moisture content 12% Shelling at low moisture content 0.1% Transportation of grains 0.5-1% Storage in small warehouses and by farmers 2% (UNIDO, 2012)
	Vegetables	Postharvest losses of cassava in Central Lampung Postharvest operation Harvesting 0.5-3% Transportation 0% Delay in the temporary pool site 715% Quality checks by receiving industry 835% Shallot- 40% (UNIDO, 2012)
Lao PDR	cereal crop	Quality loss during transportation. Rice 20% (Genova et. al., 2006)
	Fruits and Vegetables	Vegetables aggregate high postharvest losses (25-40%) Postharvest losses in both domestic and export supply chains, farmers incurred the highest loss of slightly over 30%. In the domestic supply chain, the collectors incurred about 3% loss due to physical damage as a result of careless handling during pre packing and packing operations. Wholesalers incurred much higher loss of 9.6% on average as a result of bacterial infestation (Thongsavath et al., 2012). Postharvest loss was about 48.4% in the domestic supply chain and 52.5% in the export supply chain. In both chains, farmers incurred the highest loss of about 32% due to insect damage, rotting and over-maturity. Losses incurred by collectors in the domestic supply chain (3%) were lower than that of wholesalers (9.6%) and retailers (4%).

		It is estimated that the post-harvest loss of paddy and rice grains is 20% and that milled rice is not uniform in appearance (with many broken grains); therefore, the Department of Planning of the MAF considers the post-harvest as needing improvement in order to reach the set target (JICA, 2012).
Malaysia	Cereal crops	Transportation chain from paddy fields up to the milling plant was 6.0%, Losses in paddy drying is 0.37% in 2015) The baseline losses for milling and storage are about 3.6% in 2015. (MARDI, 2017)
	Vegetables	PHLs of vegetables are estimated to be around 20–50% (Zakaria et al., 2005)
Myanmar	Cereal crops	Postharvest losses in rice Harvesting 1-3% Handling and transportation 2-7% Threshing 2-6% Drying 1-5% Storage 2-6% Processing (milling) 2-10% Total 10-37% (Government of the Republic of the Union of Myanmar, 2016)
	Vegetables	Vegetables: 25-40% (Government of the Republic of the Union of Myanmar, 2016)
	Common	Total-30-40% Agriculture postharvest losses in rice have been assessed as 10-37 percent. Discussions with the officials of the Department of Agriculture revealed that the losses occurring during rice postharvest operations amount to, on an average, 15 percent of the total production. The postharvest losses occurring in pulse crops have been estimated to be 5-7 percent and in fruits and vegetables as high as 25-40 percent. (Government of the Republic of the Union of Myanmar, 2016)
Philippines	Cereals	Rice: 40% Maize: 12%(PSA, 2015) The major postharvest operations for rice consisted of harvesting, pilling, threshing, drying and marketing. Storage of paddy to wait for a better price is generally not practiced by the farmers. Farmers retain and store only a portion of their harvest for home consumption. Traders are generally involved in hauling paddy from farm to their respective stations, drying, storage and marketing while millers/wholesalers are not only involved in milling, storage and distribution but also in drying or re-drying. (Cruz and Calica, 2016)
	Vegetables	Postharvest loss of some major vegetables in Philippines: Carrot: 7-12% Cabbage: 29% Eggplant: 10-40% Tomato: 11-38% Among the agricultural produce in the Philippines horticultural crops contribute to 44% of the total volume of food crops contribute to 44% of the total volume of food crops. These crops are important contributors to the Philippine economy in terms of export earnings. Average post-harvest losses are 42% for vegetables and 28% for fruits. Losses are highest for pineapple at 30-40% and banana which can reach to as high as 35%. These general estimates are supported by a few studies of specific commodities. For one trial shipment of 'Saba' cooking bananas from

		<p>Tupto to Manila, a loss of 20% was reported. Most post -harvest mango losses are the result of disease, but there was also a general weight loss of 6 -10% from dehydration, while the comparable weight loss for papaya was 13%. Common causes of postharvest losses are diverse, but the most common are over ripening, disease, harvesting when the fruit is too immature, and mechanical damage.</p> <p>In Philippines post harvest losses of vegetables identified losses in the range of 20 to 40%. Cabbage losses were amongst the highest, at 20 to 30%. Most of this was from trimming and transportation losses. Loss of garlic in the Philippines was 20 to 42%, which is high compared to most other countries. (AARDO workshop, 2010)</p>
	Fruits	<p>Banana: 3-30% Calamansi: 5-32% Mango: 2-33% Papaya: 27-44% Pineapple: 4% Calamansi: 5-32% Papaya: 27-44% Carrot- 7-12%(AARDO Workshop Report, 2010)</p>
Thailand	Cereal crops	Rice loss (5-10)% in the dry season (Wolf, 2012)
	Vegetables	<p>Post-harvest losses of vegetables account for 30% The postharvest losses of vegetables shipped by truck from production sites around Chiang Mai, in northern Thailand, to packing stations can be high as 60% for cabbage and tomato, 50% for head lettuce and cauliflower, 30% for bell pepper and 17% for Chinese cabbage. (Chang, 2017; Wolf, 2012)</p> <p>The percentage losses vary according to season, but can all be reduced significantly by improved containers and packaging material. Physical damage to head lettuce shipped from Chiang Mai to Bangkok was reduced from 35.8% to 12.6% when rigid plastic crates were used in place of conventional bamboo baskets. (Boonyakiat, 1999, Extracted from Kitinoja et al.,2015).</p>
	Fruits	<p>20-50% of fruits (Chang, 2017)</p> <p>Quality loss at the Orchard: Anthracnose disease 62.8% Fruit cracking 12.5% Fruit bruising 9.4% Other 15.3% lose 23,463* million baht/year * 40 baht/kg</p> <p>Quality loss during transportation Bruising 45.6% Anthracnose disease 44. 3% Ooze sap 5.8% Other 4.3% Loss 30,675* million baht/year</p> <p>Quality loss at the market Anthracnose 63.2% Bruising 29.0% Other 7.8% Loses 19,758* million baht/year (* 40 baht/kg) (Chinaphuti, 2013)</p>

Vietnam	Cereal crops and vegetables	Harvesting: Rice 2-3% Storing:2.6% Distributing: Rice -0.9% Cassava-43,979ton (Tuan, 2016) Vietnam's post harvesting losses accounted for 10 per cent of rice production, 10-20 per cent of root and tuber crops, and 10 -30 per cent of fruit and vegetables (FAO,2015)
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C. WestAsia

Iran	Cereal crops	Postharvest losses of rice: Harvest 0.6% Threshing 0.5% Drying 6% Quantitative losses 4% Broken 22% rice (Roughiah, 2016) Corn Losses harvesting stage 0.5 - 2 % cutter plane losses 0.5 - 1 % masher unit losses 0.2 – 0.4 % separator losses 0.04 – 0.2 % Barley and other cereals 10-15% Wheat loss total 15%. transportation wastes 5.5% winnowing wastes 0.2% silo (store) wastes 4% transformation waste 5% (FAO, 2012)
	Miscellaneous crops	PHLs of some miscellaneous cr ops including vegetables: Tea 7% Mushroom 10% Saffron 0.006% Medicinal 15% Cut flower 33% (Jowkaret al., 2005)
	Fruits	Some tropical and subtropical crops in Iran. Banana 6% Mango 6% Orange 8% Sour Orange 8% Tangerine 9% Sour lemon 6% Palm date 8% Fig 9% Pomegranate 7% Cherry 9% Peach 9% Plum 9% Grape 13% Strawberry 13% (Jowkaret al., 2005)

D. Pacific

Fiji	Vegetables	PHLs of Tomato: loss due to rots during ripening 8.8% loss during packing due to failing to ripe 8.9% Damage during transportation 0.13% Thrown away by vendor due to over ripe or rots 6.4% Commercial post-harvest loss- 32.93% (from farm to vendor) May project to further 14.45% loss if the fruit is not consumed within 48 hours (Kumar and Underhill, 2016)
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In South and South East Asian countries, wastage and food losses occur mainly at the early stages of the food value chain and can be linked to financial, management, and technical constraints in harvesting techniques as well as storage and cooling equipment. Strengthening the supply chain through the direct support of farmers and investments in infrastructure, transport, as well as in the development of the food and packaging industry can help reduce the amount of food wastes and losses. In middle- and high-income countries, food is wasted and lost mainly at later stages of the supply chain. There is no coordination between entities in the supply chain as a factor contributing to post-harvest losses. Farmers' agreements can help to increase the level of this coordination.

Losses in storage represent the maximum part of all losses after harvest for cereals, oil, and legume plants, in developing countries, and negatively affect farmers' incomes. Most harvested crops are stored in traditional storage structures, which are currently not efficient to prevent invading insects, pests, or molds during storage and lead to bigger losses.

Although the exact information on the types of PHLs of fruits and vegetables are really inadequate, the major losses occur in case of fruits and vegetables as their quality fall very rapidly. These happen from the very onset of harvesting to subsequent stages in the supply chain. As already told, in less developed nations of CIRDAP, this occurs mostly in the earlier market chains. The inadequate infrastructure and other physical facilities along with the economic insolvency play a greater role of such spoilage of fruits and vegetables.

In case of Pacific country like Fiji, the diversity and volume of production are lesser than other CMCs. As a whole the PHLs of vegetables and fruits are higher like South Asian countries. The improvements in infrastructure and value addition processes are imperative to upgrade the present scenarios. Supportive Government policies are also very much essential for gradual advancements in this sector.

In South East Asian countries of CIRDAP, development occurred in supply chain and value addition processes of fruits and vegetables to a better extent. Also the part of consumption process improved much. The economic capacity of the producers is better in these countries excreting a positive influence on total supply chain and value addition stages. Having a better educational status, the consumers are also more aware of the loss of food and their reduction mechanisms. Thus, it is assumed that a better scenario is achieved in this regard.

In case of Iran, the climatic condition and other production factors vary slightly from other CMCs. Due to these differences; PHLs are slightly lesser in Iran. Yet, up-gradation is very much needed in reducing the losses at various stages of supply chain for fruits and vegetables. The overall government policy formulation and proper implementation remain as the major consideration to be cared of.

3.5 Major causes of post-harvest loss

Different reasons are causes for postharvest losses (PHLs) but main causes of fruits and vegetables post-harvest losses in developing and emerging markets are (FAO, 2015) due to poor:

- (i) postharvest handling
- (ii) packing and packaging
- (iii) infrastructures and connectivity
- (iv) cold chain, transport and climate change
- (v) storage facilities
- (vi) marketing information and pricing
- (vii) education and postharvest research and development (R&D)
- (viii) processing capacity
- (ix) investment capacity and credit access, and
- (x) quality standards and control

Postharvest losses vary greatly among commodities and production areas and seasons. As a product moves in the postharvest chain, PHLs may occur from a number of causes, such as improper handling or bio deterioration by micro-organisms, insects, rodents or birds.

An important factor in developed countries is that a large amount of the food produced is not eaten but discarded, for reasons such as it was left on the plate after a meal or it passed its expiry date. In contrast, failure to consume available food in Less Developed Countries (LDCs) is not a reported concern; instead the low-quality food remaining in markets at the end of the day is sustenance for the very poor. The issue in LDCs is inefficient postharvest agricultural systems that lead to a loss of food that people would otherwise eat, sell or barter to improve their livelihoods (Hodges et al., 2010).

The causes of food losses and waste in low-income countries are mainly connected to financial, managerial and technical limitations in harvesting techniques, storage and cooling facilities in difficult weather conditions, infrastructure, packaging and marketing systems. Given that many smallholder farmers in developing countries live on the margins of food insecurity, a reduction in food losses could have an immediate and significant impact on their livelihoods (Anonymous, 2014). Yet, the main causes of postharvest losses in CMCs are summarized below in Table 2.7 based on limited information available.

As the loss or wastage of fruits and vegetables vary significantly due to socioeconomic development of the country and its geo-political situations, the grouping of almost similar countries have been done to achieve inclusive ideas of the concerned matters. The CMCs are also grouped into several numbers in the same way for other issues of postharvest as well.

Table 2.7 Major causes of post-harvest loss

A. South Asia region

Post-harvest losses of fruit and vegetable in supply chain occur due to several causes and are affected by couple of factors. Having almost similar socio-economic and climatic conditions, the South Asian countries are grouped together to present the concerns in a comprehensive way.

Country	Major causes of postharvest loss
Afghanistan	<ul style="list-style-type: none"> ▪ Both pine nuts and peanuts sub-sectors are constrained by the lack of good roasting equipment and technology as compared to Pakistan. As a result, most of the unroasted peanuts are exported to Pakistan where the roasting costs are much lower and then re-exported to Afghanistan at twice the cost. ▪ Lack of facilities to support trade exists here. There are no facilities for cold storage, shelling, poor roasting equipment and poor packaging options. The current Industrial Park does not yet have these capabilities. ▪ Some of the dried products purchased during the season are stored in three underground facilities in different market areas within the city. These provide a slightly longer storage period being less exposed to the hot weather, however far less than if refrigerated. ▪ Limited electrical power is a constraint affecting both cold storage and processing facility considerations. ▪ Poor road conditions that result in prolonged exposure to hot weather and increased product deterioration and damage of both inbound raw material and outbound processed goods. ▪ Lack of any financial support is another major cause. There are no financial agencies supporting traders. Little private sector investment from the potential businessmen (Kuhn, Hayashi and Lea, 2006).
Bangladesh	<ul style="list-style-type: none"> ▪ Mechanical loss to the fruits is caused by careless handling during harvesting, packing, transportation, storage etc. ▪ Microbial action; Fruits and vegetables are more prone to microbial spoilage caused by fungi, bacteria, yeast and molds. ▪ Environmental factors, temperature and humidity are also major factors of post-harvest loss. ▪ Inadequate harvesting, transportation, storage and marketing facilities lead to the conditions favorable for secondary causes of loss. ▪ Longer shipment and distribution period also causes heavy losses (Tuteja, 2017).
India	<ul style="list-style-type: none"> ▪ Processing level presently being extremely low, the wastage levels are very high resulting in colossal wastage of national wealth running in thousands of crores (National Food Processing Policy, 2017) ▪ Limited availability of trained human resource in frontier areas of science ▪ Low investment in research and regional imbalance in resource allocation ▪ Lack of sufficient infrastructural facilities for the farmers ▪ Lack of economies of scale limits private sector participation in near-farm primary processing activities (Ganesh et al.,2018).
Nepal	<ul style="list-style-type: none"> ▪ Insects were major cause for grain loss followed by rodents and molds. ▪ The main causes of post-harvest losses in survey areas were traditional methods of storage. Less than half of the respondents were aware of moisture content and its role on seed storability. Maize grain or seed loss in storage range were 10-20%. Sun drying was the pest management practices and very few farmers used chemicals insecticide and botanicals against storage pests. Important causes for low adoption of recommended post-harvest technologies were economic and social (Bandhari et al. 2015).
Pakistan	<ul style="list-style-type: none"> ▪ Disease caused by fungi and/or bacteria ▪ Physical injuries due to insects, mechanical force, chemicals, heat or freezing ▪ Abiotic disorders resulting from storage conditions that upset normal metabolism when the product is rejected further down the marketing chain ▪ Other factors of postharvest losses in addition to genetic traits, environmental factors such as soil type, temperature, and wind during fruit set, frost, and rainy weather at harvest can have adverse effects on storage life, suitability for shipping, and quality (Khan, 2015). ▪ The main causes of food losses are imbalanced use of inputs, faulty irrigation systems, diseases, insect and fungi damages, inappropriate harvesting practices, excessive supplies, poor grading and packaging, poor handling during transportation and storage etc. (National Food Security Policy, 2017) ▪ Proper machinery is not being used by the farmers in harvesting and threshing, which results in damage to the quality of rice. The storage capacities for exports are insufficient (Khan and Khan, 2010).

Sri Lanka	<ul style="list-style-type: none"> ▪ Inefficient transportation and storage methods are resulting in as much as one-third of Sri Lanka's produce going to waste. ▪ Harvesting at an incorrect stage of maturity is a major cause of post-harvest losses. ▪ Harvesting method affects composition and quality of fruits, as it causes maturity variations, extent of physical injuries etc. ▪ Damage due to harvesting devices – for harvesting there are special tools, equipment that are developed. These should be used to minimize physical damage to the harvest, if damaged it will be a focus for infection. (Kodippili, 2016)
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B. South East Asia

Indonesia	<ul style="list-style-type: none"> ▪ Grain spillage, incomplete separation of the grain from chaff, grain breakage due of excessive striking are some of the major reasons for losses during the threshing process in Grain Supply chain. Delay in threshing after harvesting of crop results in significant quantity and quality loss, as the crop is exposed to atmosphere, and is susceptible to rodents, birds, and insect attack. ▪ As in the case of harvesting, lack of mechanization is the major reason for this delay that causes significant losses. High moisture accumulations in the crop lying in the field may even lead to start mold growth in the field (Kumar and Kalita, 2017).
Lao PDR	<ul style="list-style-type: none"> ▪ Lack of quality consciousness among stakeholders within the post-harvest system, despite pressure from export markets and from urban consumers. ▪ Limited scope for economies of scale in the production of commodity crops due to small-scale agriculture in the production of these crops ▪ Inadequate private and public sector support for post-harvest R and D ▪ Insufficient land and capital investment resources to permit the sector to develop in line with demands and potential. ▪ Inadequacy of basic infrastructure, which reflects, limited government support for the post-harvest sector, given the focus on industrial development during the last few decades (Genova et al., 2006). ▪ Most common causes of loss were physical damage and bacterial soft rot. (Thongsavath et al., 2012).
Malaysia	<ul style="list-style-type: none"> ▪ The key issues and challenges in the development of the domestic agro-food industry in Malaysia with FSFS issues taking center stage can be seen in limited land resources, idle land, lack of workforce, lack of infrastructure, and incidence of pests and diseases. (Sa'ari, 2012)
Myanmar	<ul style="list-style-type: none"> ▪ Farmers and other stakeholders in the supply chain lack basic knowledge and awareness of the factors that could compromise productivity, quality and safety during postharvest handling, and processing operations ▪ Inadequate capital for adoption of improved postharvest and agro processing technologies is another constraint confronted by the rural sector ▪ Lack of adequate knowledge in the rural sector of the prevailing market situation for agricultural/food products is another drawback in developing postharvest and agro processing activities in the rural sector. ▪ Insufficient electricity supply in rural areas for implementing improved postharvest and agro-processing technologies is another constraint faced by the rural sector in Myanmar (NAPA, 2016)
Philippines	<ul style="list-style-type: none"> ▪ For cereal crops, lack of investment in Rice Drying facilities whether by government or by industry here. Some Integrated Rice Drying and Milling not financially sustained due to lack of users. All farmers are not receptive to having their harvest dried for a fee and prefer to use the roads for free. ▪ For vegetables, lack of proper storage cause wide fluctuation in prices of basic vegetable due to fluctuation in supply within the year due to seasonality or weather situation (www.map-abcdf.com.ph/documents/presentations/ Agribusiness) ▪ For fruits common causes of postharvest losses are diverse, but the most common are over ripening, immaturity, and mechanical damage.

	<ul style="list-style-type: none"> ▪ Harvesting techniques also contribute to losses (FAO, 2013). Postharvest losses can happen due to lack of proper containers for packing the harvested produce. ▪ The temperature is one of the factors for weight loss of fruits and vegetables. The cumulative effect of temperature might have affected the weight loss of mango but it did not affect the quality even during the transit time (Rapusas and Serrano, 2010). ▪ The absence of storage facilities leave the farmers no choice but to sell their product at low market prices or leave their product unharvested or face the risk of total loss in the case of delayed collection by transporters, wholesale or retail stores. This is often the case for most of the farmers in the country. ▪ Lack of proper packaging at the farm level results in high percentage discards after transport (Nueva and Apaga, 2010).
Thailand	<ul style="list-style-type: none"> ▪ Inefficiencies in infrastructure, distribution, and transportation ▪ Inadequate Policies, programs, plans, regulation, price, information ▪ Socio-economic factors like attitude, custom, income, credit and education ▪ Adverse weather/ Oversupply (Chinaphuti, 2013). <p>Causes for Rice post-harvest Loss-</p> <ul style="list-style-type: none"> ▪ Delayed or early harvest ▪ Varieties susceptible to diseases and pests ▪ Poor soil condition, e.g. wet soil ▪ Poor handling, threshing or shelling practices ▪ High temperatures ▪ Moisture in storage area (Wolf, 2012)
Vietnam	<p>Paddy Harvesting conditions are found to have a considerable impact on losses along the rice value chain:</p> <ul style="list-style-type: none"> ▪ Using manual methods for harvest always prolongs harvest time, especially under unfavourable weather conditions, leading to a high loss rate. ▪ Besides, hired labour for Paddy Harvesting is becoming increasingly common, but poor labour awareness and hurry in cutting causes more grain to fall and unharvested ears of rice to remain in the field. Compared to mechanical harvest by combine harvester, PHL in manual harvest is higher. ▪ Presently, all of the harvested paddy is transported by simple carts driven by humans or animals, powered vehicles or small trucks. Hence, the ratio of grain fall is limited. The rice is usually transported to the ends of the path at the edge of paddy field or an empty site near the field to be threshed. ▪ Threshing activities often take place on home yard or empty ground sites. Rice grain blown with straw is high, because the rice is wet at threshing which causes postharvest loss. <p>For Maize</p> <ul style="list-style-type: none"> ▪ Currently common methods are phosphine fumigation in storage facilities. Losses of maize after six months of storage without preservatives to eradicate insects can reach up to 20 percent. ▪ During the milling stage losses occur, similar to rice, due to inappropriate technology. Many milling plants are too old and outdated to be used, so that losses for maize (grain) reach four percent at this stage <p>For Cassava</p> <ul style="list-style-type: none"> ▪ In terms of storage, farmer's households only keep enough cassava for their family needs. Storage lacks innovation and use of scientific and technical achievements to prevent pests, mold and micro-organisms. With conventional ways of storage, where the dried cassava is stored on the floor of house on stilts, the loss rate is very high for cassava after only four months, mainly because of moths (VU THI MY HA, 2019)

C. West Asia

Iran	<ul style="list-style-type: none"> ▪ Poor postharvest handling is the result of limited facilities and low-grade human resources. Postharvest facilities for horticultural produce pale in comparison of those developed for other food crops. ▪ Postharvest loss accounts for direct physical losses and quality losses that reduce the economic value of crop, or may make it unsuitable for human consumption (Kader et al. , 2012).
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D. Pacific

Fiji	<ul style="list-style-type: none"> ▪ Unstructured grading and packaging system ▪ Poor infrastructure ▪ Poor knowledge of postharvest handling ▪ High day-time temperature ▪ Limited processing facilities ▪ Insect attack ▪ Diseases and poor field sanitation (Kumaret al, 2016).
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3.6 Effects of post-harvest loss

Economically, food losses have a direct and negative impact on the income of both farmers and consumers. Food waste leads to wasteful use of chemicals like fertilizers and pesticides, more fuel used for transportation, more rotting food. We are also creating more methane, which is one of the most harmful greenhouse gases that contribute to the climate change. With the large amount of food going to landfills, we make a big contribution to global warming.

Effects of postharvest losses are paramount excreting their effects on biodiversity loss, wastage of the 1/3 of the world fertile land areas, blue water footprint, increased carbon footprint and the acceleration of climate change and economic consequences. However, these effects vary in country to country situations. The major available consequences are presented in the following Table (table 2.8).

Table 2.8 Effect of post-harvest loss

A. South Asia

Country	Effect
Afghanistan	<ul style="list-style-type: none"> ▪ Due to improper management and poor knowledge of growers about 30% to 40% losses of agriculture production (Mirwais and Yamada, 2017). ▪ Loss of moisture from the surface of the product through evaporation, transpiration and respiration. Loss of moisture from the product results in shriveling and loss of market value and can lead to wastage ▪ Interruption in the normal metabolic activity of the products, due to either extremely low or high temperature. At sub-optimal temperatures, the products may exhibit the physiological disorder chilling injury. At temperatures above 30°C, the product overheats and boils. In this case, its external appearance deteriorates and it spoils quickly ▪ Invasion of the products by various pathogens results in fruit rot. Injured and senescent tissue are more sensitive to the attack from decay causing microorganisms (Masood, 2011).
Bangladesh	<ul style="list-style-type: none"> ▪ PHL can be reduced, thereby increasing the amount of food available for consumption by farmers and poor rural and urban consumers (Golleti, 2003). ▪ The benefits to consumers from reducing losses include lower prices and improved food security. In addition, postharvest activities such as processing and marketing can create employment (and thus income) and better food security in the agricultural sector. ▪ Techniques to reduce food losses require cultural and economic adaption. This is so because all food losses occur at a particular socio-cultural environment. The issue of food losses is of high importance in the efforts to combat hunger, raise income and improve food security in the world's poorest countries (FAO, 2011).
India	<ul style="list-style-type: none"> ▪ Processing level presently being extremely low, the wastage levels are very high resulting in colossal wastage of national wealth running in thousands of crores (National Food Processing Policy, 2017) ▪ Limited availability of trained human resource in frontier areas of science ▪ Barriers such as lack of awareness, limited access to finance and few near-farm markets for primary processed produce restrict SHF adoption of best practices and mechanization. ▪ Lack of economies of scale limits private sector participation in near-farm primary processing activities (Ganesh et al., 2018).

Nepal	<ul style="list-style-type: none"> ▪ Huge amount of fruits and vegetables are wasted everyday due to the lack of proper post-harvest facilities at the fruit and vegetable wholesale markets. ▪ Uncertainty about food distribution is created as a consequence of gigantic post-harvest losses in the areas without access of roads due to high cost of transportation. ▪ Uncertainty about food distribution is occurred in the areas without access of roads due to high cost of transportation (Devkota et al., 2014).
Pakistan	<ul style="list-style-type: none"> ▪ Cultural practices may have dramatic impacts on postharvest quality. Good Agricultural Practices during harvest operations and any subsequent postharvest handling, minimal or fresh-cut processing, and distribution to consumers must be developed (Khan,2015).
Sri Lanka	<ul style="list-style-type: none"> ▪ Environmental: Temperature influences uptake and metabolism of minerals, thus transpiration of fruits increase with high temperatures. ▪ Heavy rains/severe water stress results in increased sunburn of fruits, irregular ripening. Moderate water stress reduces fruit sizes and increases total soluble solid content, acidity and ascorbic acid (Kodippili, 2016).

B. South East Asia region

Country	Effects
Indonesia	<ul style="list-style-type: none"> ▪ Poor postharvest handling in Indonesia is the result of limited facilities and low-grade human resources. Postharvest facilities for horticultural produce pale in comparison of those developed for other food crops ▪ Postharvest loss accounts for direct physical losses and quality losses that reduce the economic value of crop, or may make it unsuitable for human consumption. ▪ Economic impacts represent a wasted investment that can reduce farmers' incomes and increase consumers' expenses such as seeds, fertilizers, and pesticides. ▪ Environmental impacts inflict a host of impacts, including unnecessary greenhouse gas emissions and inefficiently used water and land, which in turn can lead to diminished natural ecosystems and the services they provide (Adiandri, 2017).
Lao PDR	<ul style="list-style-type: none"> ▪ Air pollution, water pollution, land occupation, biodiversity loss, deforestation, loss of wild landscapes (grasslands, wetlands), scarcity of energy, resources, land and water ▪ Increased public costs, increased labor demand and food prices, increased pesticide and nitrate exposure, increased safety and displacement risks, reduced access to ecosystem services are the effects of post-harvest losses in Lao PDR (Bennett, 2018).
Malaysia	<ul style="list-style-type: none"> ▪ Postharvest losses (PHL) of paddy can be defined as losses that occur due to spills, human negligence and incompetence during the postharvest handling operations, inefficient processing system that results in broken rice and improper storage resulting in unpleasant odors, discoloration and insect attacks (Zahari, 2012).
Myanmar	<ul style="list-style-type: none"> ▪ The government has allowed the private sector to import and produce fertilizer for distribution. Pesticide use in Myanmar has increased because of the need for improved production and lower postharvest losses. At the same time, there is concern about food safety, so pesticide use is restricted to the lowest possible level. ▪ Post-harvest losses represent a significant threat to food security and farmer incomes worldwide. It is inefficiency in the global food production system that is avoidable (McNamara and Tata, 2015).
Philippines	<ul style="list-style-type: none"> ▪ Small-scale post-production machines and simple, yet useful, post-harvest technologies are the most appropriate to rural areas for employment generation. Though, it would take some time to realize the benefits derived from post-harvest technologies introduced (mainly due to the constraints in the industry), a great contribution in the economy would be accounted once these technologies take positive effects to the almost 90% small farmers in the country.

	<ul style="list-style-type: none"> ▪ The proper post-harvest handling and technologies would not only reduce losses and improve the quality of produce but it will also help the people establish their own farm-level secondary handling and value-added processing businesses, resulting in more job opportunities, thus empower and improve the lives of farmers (unapcaem.org/Activities Files/A20/10 Philippines.pdf).
Thailand	<ul style="list-style-type: none"> ▪ Effects of Rice post-harvest loss <ul style="list-style-type: none"> ✓ Losses in quality and quantity in all stages ✓ Low harvesting yield ✓ Losses in quality, such as high level of broken milled rice(Wolf, 2012) ▪ Effects of Maize post-harvest loss <ul style="list-style-type: none"> ✓ Losses in quality and quantity in all stages ✓ Quality decreases, increased vulnerability to pests and diseases ✓ Losses in quality, possible production of mycotoxins, Swelling and germination of grain(Wolf, 2012) ▪ Effects of Cassava post-harvest loss <ul style="list-style-type: none"> ✓ Losses in quality and quantity in all stages ✓ Losses in quantity, High % of root left in the ground ✓ More workers needed for machine ✓ Cassava chips fermented (Wolf, 2012) ▪ Postharvest food losses can have long-reaching impacts on production, consumption, food security, the environment, and food safety. ▪ Effects on the Value Chain: Wasted food due to postharvest processing can result in lost calories and lowered nutrition for consumers, which immediately reduces food security for the community, particularly, householders and small scale producers. ▪ Effects on the Environment: Postharvest food losses can place direct demands on the environment though either the incorrect disposal of waste leading to pollution and odor or in waste disposal costs. Waste can be turned into gains and this has been achieved for cassava waste in West Africa and Asia (Sergeant et al., 2015). ▪ Effects on Food Safety: In food processing and production, where any food which is unsafe is part of a batch, lot or consignment of food of the same class or description, it can be presumed that all the food in that batch, lot or consignment is also unsafe. In these instances, postharvest food losses can increase leading to increased costs to the consumer and losses in income for the producer (Tomlins et al., 2016).
Vietnam	<ul style="list-style-type: none"> ▪ Vietnam encounters significant monetary losses for post-harvest food loss. ▪ Postharvest losses have a cumulative effect, contributing to waste and food insufficiency (Kader, 2005, Kader, 2010). ▪ Environmental effects: These losses have a negative effect on the national production volumes as well as the perceived potential revenue (Munhuweyi, 2012).

In South Asian countries, postharvest loss accounts for direct physical losses and quality losses that reduce the economic value of crop, or may make it unsuitable for human consumption. PHL represents a wasted investment that can reduce farmers' incomes and increase consumers' expenses. It inflicts a bundle of impacts, including unnecessary greenhouse gas emissions and inefficiently used water and land, which in turn can lead to diminished natural ecosystems and the services they provide. And thus, weaken food security systems of the country. Institutional policy assistance and field level implementation of those policies are prime concerns to reduce impacts of PHL of fruits and vegetables in South East Asian countries under CIRDAP.

C. West Asia Region

Country	Effect
Iran	<ul style="list-style-type: none">▪ Food insecurity and mal nutrition are the main effects of post-harvest loss since we see that low productivity of small-holder farmers, their limited access to land, combined with water shortage, excessive ground water withdrawal, inadequacy of irrigation systems create excessive post-harvest losses.▪ From an economic point of view, the sum of the losses in quantity and quality of the products inevitably means losses of money (Sokoutfar, 2016).

As a CMC, Iran is a bit different in its geographic and socioeconomic condition compared to other Asian countries of CIRDAP. Its dry climatic condition allows products to decay less in the supply chain. But their limited accesses to land, combined with water shortage, excessive ground water withdrawal, inadequacy of irrigation systems create excessive post-harvest losses. Thus, the PHLs are a bit higher having greater impacts on economic and environmental matters.

D. Pacific region

Simply being away from and different in nature compared to other CMCs, Fiji shows a bit different characteristics in the production of cereals, fruits and vegetables and their PHLs. Yet, some common phenomena as impacts of PHLs show a similar trend of effects like decrease in product's shelf life, reduced market opportunity and poor prices, low farm income, unsafe produces for the consumers, limited access to nutrient food etc.

Country	Effect
Fiji	<ul style="list-style-type: none">▪ Unsustainable food supply and value chain▪ Increase of food wastage▪ Poor quality products▪ Decrease in product's shelf life▪ Limited market opportunity and poor prices▪ Low farm income▪ Unsafe food products for the consumers▪ Limited access to nutritious food (Kumaret al., 2016).

From the varied perspectives of PHL impacts, customized approaches may be needed to country or region specific concerns of PHLs and their management.

3.7 Challenges of post-harvest loss

The problem of food loss may be more complex to tackle, as it requires changes in the way we value and consume food. Our current consumption patterns are not sustainable. Food loss and waste are effectively linked to consumer demand, which constantly evolves and is influenced by many cultural and social factors that do not always follow economic or ecological rationality. Technological advancements and socio-economic set up may lead to varied attempts in resolving the postharvest losses and a total food waste as a whole. Under such an understanding, the different challenges in different CMCs are placed below in different categories of countries. Although it can never be the same, yet the countries are placed into different groups based on their similar geographic and socioeconomic features.

Like any production factor to affect production of fruits and vegetables, the challenges for postharvest loss matters are diversified

based on produces and countries as well. In South Asian countries, the major challenges need to be dealt with are the inadequate postharvest standards, lack of infrastructures, equipment and facilities; and are characterized by excessive losses at supply chain. There also lacks the appropriate policy and financial supports to combat PHLs of cereals, fruits and vegetables.

In case of East and West Asian member countries, the production standards are a bit better and the postharvest management has its own standard. The farmers are also aware of the consequences of PHLs at different phases of the supply chain. Yet, the problems remain in efficacy of transport, storage and retailing systems. These need further improvement to reduce PHLs. On the other hand, the consumers' awareness is needed to increase in reducing the food wastages.

The cases of Iran and Fiji are exceptional. The production of fruits and vegetables are not so diversified like others. Accordingly, their challenges in PHLs are different from other CMCs. In case of Iran, the main challenges are organizational, the collector system and the small scale farming without cooperative structure, as well as educational on good practices for preventing fruit flies, proper handling and packaging. But for Fiji, the road and transport condition are poor, famers are less aware of media information. Unstructured grading and packaging systems; poor infrastructure; poor knowledge of postharvest handling; high day-time temperatures; limited processing facilities and similar other issues are very common.

Considering the challenge variation of different CMCs, it can be assumed that the varied challenges claim for varied initiatives to resolve or reduce them. Reducing the loss after harvest, especially in developing countries, can be a sustainable solution to increase food availability, reduce pressure on natural resources, eliminate hunger, and improve farmers' living conditions (Sawicka, 2019). Cereal crops are the basis of food in most developing countries around the world. The maximum losses after harvest are estimated on the basis of calories among all agricultural products. As much as 50–60% of cereal yields can be lost at the storage stage due to the lack of technical possibilities for their proper harvesting and storage. The use of scientific storage methods can reduce these losses by up to 1–2% (Obiedzińska 2017; De Lucia and Assennato 2006).

Table 2.9 Challenges of post-harvest loss in CMCS

A. South Asia region

Country	Food	Challenges of post-harvest loss
Afghanistan	Cereals	n/a
	Vegetables	<ul style="list-style-type: none"> Challenges in processing includes the treatments which start after harvest and end before consumption: handling, transportation, refrigeration, holding, washing, freezing, canning, drying, packaging, storage, and ultimately cooking or heating; however other processes may be included (Yousufi, 2016).
	Fruits	<ul style="list-style-type: none"> Storage: The cost of storage and any loss from decay of fruit and vegetables during storage must be less than the increase in price (Yousufi, 2016). Packaging: There is no packaging standard for horticultural products in Afghanistan. However, packaging is a crucial issue because most horticultural products are fragile and highly perishable. 49% of the villages in Afghanistan pack their horticultural products in jute sacks, 36% pack in crates (mostly for fruit species); and 15% pack in baskets (mostly pomegranates) (FAO, 2004).
Bangladesh	Cereals	<ul style="list-style-type: none"> Bangladesh has been suffering significant food losses for a long time due to various reasons like, lack of modern technologies and machineries inefficient marketing systems. Government support is not sufficient in research and extension sector. Processing and preservation facilities are not sufficient. Poor handing during loading and unloading at market point (Bari, 2015).
	Fruits & Vegetables	<ul style="list-style-type: none"> The changing demand in domestic and international markets for high-value product creates challenges and opportunities. Majority of the horticultural commodities like fruits and vegetables are produced by small and marginal holders, but due to weak and fragmented value-chain, only a small percentage of the produce reaches the urban market (Minten et al., 2010).

	Vegetables	<ul style="list-style-type: none"> ▪ For the intermediaries, the predominant constraints are related to the adequate transportation and storage facilities. ▪ Lack of funds is also mentioned by some intermediaries. Intervention is crucial in the transport and storage sectors. ▪ Among the challenges, for potato rank 1st was low market price, rank 2nd was lack of marketing facilities and 3rd was lack of processing facilities during potato growing season (Hossain, 2012).
India	Cereals	<ul style="list-style-type: none"> ▪ There is a need to strengthen adaptive research and technology assessment, refinement and transfer capabilities of the country so that the existing wide technology transfer gaps are bridged. ▪ Deceleration in total factor productivity slows-down in the growth of irrigated area (Rashad, 2013).
	Vegetables	<ul style="list-style-type: none"> ▪ The biggest challenge the industry faces is power, without which the cold chain cannot be successful. States need to invest in renewable energy and provide solar energy at subsidized rates (Rashad, 2013).
	Fruits	<ul style="list-style-type: none"> ▪ Lack of cold storage facility ▪ Use of traditional method in various steps from harvesting to storing ▪ Poor transportation facility ▪ Lack of knowledge, awareness and low economic condition of the farmers (Rashad, 2013).
	Common	<ul style="list-style-type: none"> ▪ This extensive amount of losses creates great food insecurity. Food loss is a constraint to achieve the SDG 2 “ Zero Hunger”(Rashad, 2013).
Nepal	Cereals	<ul style="list-style-type: none"> ▪ Lack of adequate attention to food security at the national level ▪ Lack of local governments and inter-agency coordination and synergy for food security activities (Aulakh and Regmi, 2013) ▪ Poor storage of grain causes dramatic losses in grain post-harvest due to fungal infections and insect damage. Combined with the remote location of terrace farms and lack of frequent transport to cities(Boxall, 1984). ▪ Lack of awareness of moisture percentage of grain during storage (Devkota et al,2014).
	Vegetables	<ul style="list-style-type: none"> ▪ Lack of adequate storage, processing and conservation facilities in rural areas/ with small producers (Aulakh and Regmi, 2013).
Pakistan	Fruits and Vegetables	<ul style="list-style-type: none"> ▪ Primary factors of post-harvest losses in citrus are mechanical, physiological, pathological or environmental factors which are directly responsible. Mechanical loss is caused by careless handling during harvesting, packing, transportation, storage etc. Some insects and birds are also responsible for the mechanical injury. ▪ A significant portion of losses during the post-harvest period is attributed to the diseases caused by fungi and bacteria. Environmental factors, temperature, humidity, composition and proportion of gases in controlled atmospheric storage also play an important role. ▪ High temperature and relative humidity favors the growth of micro-organisms which cause extensive damage to the produce.
	Common	<ul style="list-style-type: none"> ▪ Poor pre-harvest measures-- adoption of poor production techniques (varieties with low shelf life, imbalance use of nutrients ▪ Insect pest and disease infestation and abiotic stresses ▪ Low tech harvesting procedures-- non-application of pre-harvest recommended treatments/practices ▪ Harvesting at improper stage and improper care at harvest; and post-harvest problems-- non-removal of field heat,

		<ul style="list-style-type: none"> ▪ Dumping produce, moisture condensation causing pathogen infestation, ▪ Pckaging in bulk without sorting and grading of produce, improper transportation and storage ▪ Distant and time consuming market distribution (Khan,2015)
Sri Lanka	Cereals	<ul style="list-style-type: none"> ▪ Awareness of improved technology ▪ Capital to acquire improved technologies ▪ Proper marketing channels and marketing facilities ▪ Price incentives for quality products ▪ Testing and certification facilities (Wasala et al., 2014).
	Vegetables and fruits	<ul style="list-style-type: none"> ▪ Awareness of improved technology ▪ Capital to acquire improved technologies ▪ Proper marketing channels ▪ Price incentives for quality products ▪ Infrastructure facilitates ▪ Testing and certification facilities (Bamunuarachchiet al, 2010)

B. South East Asia Region

Country	Food	Challenges of post-harvest loss
Indonesia	Cereals	<ul style="list-style-type: none"> ▪ Climate change is also considered to be another challenge as, Indonesia is located in equator so it is susceptibly exposed by climate change impacts which cause less optimal farming production and post-harvest activities (Kumar and Kalita, 2017).
	Vegetables	<ul style="list-style-type: none"> ▪ The cold storage managed by farmers collapsed because of the high management costs and the storage was less suitable for storing seeds. In addition, the availability of electricity will be a challenge (Indonesian postharvest loss alliance for nutrition, 62391229-00, 2016)
	Fruits	<ul style="list-style-type: none"> ▪ Technical equipment is only part of the solution. The main challenges are organizational, the collector system and the small scale of farming without cooperative structure, as well as educational on good practices for preventing fruit flies, proper handling and packaging. (Indonesian postharvest loss alliance for nutrition, 62391229-00, 2016)
Lao PDR	Vegetables	<ul style="list-style-type: none"> ▪ Growing conditions in the wet season are unfavorable, especially for some the high value vegetable crops ▪ Small scale production with limited connectivity to market ▪ Limited awareness in the value of using quality inputs ▪ Effective management of water resource during the dry season and availability of land and drainage problems during the wet season ▪ Ineffective pest management programs leading to an over-reliance on chemical control – exacerbated during the wet season(JICA, 2012).
	Common	<ul style="list-style-type: none"> ▪ Poor postharvest management ▪ Food safety risk (pesticide and microbial) posed by fresh produce ▪ Poor understanding of market opportunities – supply rather than demand driven (The Centre for Global Food and Resources,2015). ▪ Poor understanding of market opportunities – supply rather than demand driven ▪ Fragmented flow of information along value chains ▪ Lack of industry coordination (Cambodian Vegetable Forum Handbook, 2017)
Malaysia	Cereals	<ul style="list-style-type: none"> ▪ Unavailability of appropriate tools and equipment is a big problem. Most of the growers do not have appropriate tools and equipment for harvesting, cleaning, waxing, and packaging, grading and cooling.

		<ul style="list-style-type: none"> Losses at distribution level; retailers face problems in adjusting supply to demand. Every day huge quantities of fresh horticultural products are thrown away due to rotting or torn packaging and poor management (<i>Mohamed, 2017</i>).
	Vegetables	<ul style="list-style-type: none"> Lack of knowledge and information is evident. Fruits and vegetables have soft structures and thus handling with inadequate knowledge on proper harvesting, packaging, transporting and marketing methods can rough up the produce resulting in huge postharvest losses Inadequate transportation facilities, breakdown and delay in transportation of perishable commodities are common occurrences in the local markets, particularly during the rainy season, and as such are major contributors to postharvest losses (<i>Sabuddin, 2017</i>)
	Fruits	<ul style="list-style-type: none"> Acute shortage of labor Lack of post-harvest handling and storage facilities Lack of knowledge and awareness on post-harvest handling (<i>Zakariya et al., 2005; Zabeda, 2014</i>) Post-Harvest handling-a major problem in the development of the fruit industry in Malaysia. Rough handling-resulted in severe damage and losses to the fruits when the products reach to the market. The need for proper handling of produce at postharvest stages is not given proper attention-most cases better handling practices may not necessarily benefitted fruit producers in terms of monetary return. (<i>Sa'ari, 2012</i>).
Myanmar	Cereals	<ul style="list-style-type: none"> There is concern about food safety, so pesticide use is restricted to the lowest possible level. (<i>SEARCA, 2017</i>)
	Vegetables	<ul style="list-style-type: none"> There are many issues and requirements for food safety and quality standards under primary food production. Many in Myanmar related to agricultural production concern lack of production knowledge, inadequate postharvest processing as well as poor facilities and infrastructure in production areas. There is a need to supply quality seed for good quality and high yields; to provide postharvest technology and facilities; to apply GAPs (to be issued by the MoAI); and to organize organic farming and contract farming (<i>NAPA, 2016</i>)
	Fruits	<ul style="list-style-type: none"> Particular issues include significant price fluctuations (even on a day-to-day basis), transportation problems, insufficient buyers and lack of cold storage/ice facilities. Research systems are plagued with problems including overlapping mandates, leadership and institutional arrangements, as well as suboptimal human, physical and financial resources. Operational linkages between the various research institutions and among research, extension, and training organizations within the public sector are weak. The exchange of scientific information and research results among research organizations, and with research, extension and training institutions is also limited. Human resources are inadequate in terms of knowledge, skills and motivation. Hence, there is an urgent need to strengthen the human and material resources of the present research and development organizations to undertake both pure and applied research in postharvest and agro-processing technology (<i>NAPA, 2016</i>).
	Common	<ul style="list-style-type: none"> Farmers are not able to maintain quality seeds for the next season and this has serious implications on food security for dry zone farmers^[1] High crop loss due to lack of drying facilities Quality deterioration due to Mold Development Paddy price: reduced 50%, or even “nobody want to buy “due to lack of drying facility for the wet paddy (<i>FAO, 2016</i>).

Philippine	Common	<ul style="list-style-type: none"> Wide economic gap between farmers and businessmen, the major recipients of modern post-harvest technologies are usually traders and processors. The farmers, due to inadequacy of capital, cannot afford to buy appropriate post-harvest machineries. Low adoption of improved post-harvest facilities, the absence of strong linkage between producers and the market can effectively limit the benefits that can be derived from them. Weak information system Failure of majority of farmer's cooperative(unapcaem.org/Activities Files/A20/10 Philippines.pdf).
	Cereals	<ul style="list-style-type: none"> Low milled rice recoveries High milling losses(Salvador, 2016).
	Fruits	<ul style="list-style-type: none"> Quality deterioration of fruits and vegetables due to delay in transport resulting to high transportation losses and costs(Salvador, 2016).
	Vegetables	<ul style="list-style-type: none"> High onion losses from cold storage Onion rejects due to discolored, oversized, rotten, sprouted and irregularly-shaped onions Bruising of carrots due to manual washing Inefficient soil digging equipment causing mechanical damage of sweet potato at harvest (Salvador, 2016)
Thailand	Cereals, Vegetables and fruits	<ul style="list-style-type: none"> Lack of knowledge and technology transfer to farmers Costly post-harvest infrastructure and technologies Lack of funds for research and development Lack of investment and the involvement of local manufacturers in constructing small scale need based post-harvest infrastructure Lack of awareness among policy makers and the general public about the need to reduce food losses after harvest [The High-Level Multi-Stakeholder Consultation on Food Losses and Food Waste in Asia and the Pacific Region, 2013] High cost of packaging and transportation (FAO, 2015) For rice, in some areas, however, harvest machines are in short supply and farmers have to reserve a time for harvest. This could lead to early or late harvest, because cancelling the reserved time slot with the harvest machine operator could mean that the farmer is left without harvest machine (Wolf, 2012).
Vietnam	Cereals	<ul style="list-style-type: none"> Small and scattered production, Improper drying of rice, poor storage and milling of rice under unacceptably high humid conditions, and the inappropriate use of post-harvest technology VIAEP(2016)
	Common	<ul style="list-style-type: none"> Small and fragmented farm Inadequate farmer knowledge and skills in postharvest loss reduction Inefficient marketing channel with many stages Technology and research capacity are not sufficient (harvesting, storage, preservation: 73% storage of farmers is temporary) (Dang Kim Khoi, 2017).

C. West Asia

Country	Food	Challenges of post-harvest loss
Iran	Cereals	<ul style="list-style-type: none"> At all stages, manpower involved in logistics and marketing is not fully aware of produce requirements, leading to loss in quality and value. Rural infrastructure is poor. Pre cooling is considered to be the most important unit operation Transport conditions of the vehicles -tents/covers. Inadequate two-way dialogue between government & stakeholders Inability to initiate & sustain linkage with international markets (Sokoutfar, 2016)

	Vegetables	<ul style="list-style-type: none"> ▪ Poor basic infrastructure affecting production planning & postharvest infrastructure ▪ Inappropriate & lack of adequate technology ▪ Low level of organization ▪ Small and scattered nature of cultivation (Jowker et al. 2005)
	Fruits	<ul style="list-style-type: none"> ▪ Fungal decay : Postharvest: (fungicide), heat treatment, biological control (<i>Debaryomyces hansenii</i>) ▪ Chilling injury: Postharvest Optimum temperature of storage (5°C), Air circulation ▪ Mechanical injury: Packaging and transportation(Sokoutfar, 2016)

D. Pacific region

Country	Food	Challenges of post-harvest loss
Fiji	Cereals	n/a
	Vegetables	<ul style="list-style-type: none"> ▪ Postharvest loss of tomatoes along with supply chains was 32.9% . We found out that the road conditions are poor. Also, that the packaging was not ideal. However, the key postharvest challenge in terms of quality is on the farm, because of the on-farm ripening process. ▪ The growers are also using domestic electric fan for drying tomatoes when they are facing challenges of rainy weather during harvesting and transporting to ripening location. While majority of growers had electricity supply in ripening shed, reluctance to use electric fans is largely based on additional costs. Most tomato fruits are ripened at ambient temperatures (Kumar, 2017).
	Fruits	<ul style="list-style-type: none"> ▪ Unstructured grading and packaging systems; ▪ poor infrastructure; poor knowledge of postharvest handling; ▪ high day-time temperatures; ▪ limited processing facilities; ▪ Insect attack; diseases and poor field sanitation are the main factors contributing in the fruit and vegetable losses. (Kitinoja <i>et. al.</i> , 2015)
	Common	<ul style="list-style-type: none"> ▪ Lack of understanding from both farmers and extension staff on the importance of post-harvest practices. ▪ Farmers have low access to information, technology (on farm process) and finance. ▪ The obstacles and challenges range from unfamiliarity with the new crops and with the international standards and specifications of the demanding buyers. ▪ There are also complicated export procedures to deal with, new harvesting and packaging methods and the need to finance on-farm investment such as plastic canopies, net houses, pump sets and irrigation equipment. ▪ The growing and post-harvest practices for new crops such as coriander, Italian basil and rocket salad, are very different and more demanding than for the bulky cabbage which they are used for growing (FAO, 2015).

3.8 Interventions to minimize post-harvest loss

Nowadays, interventions in PHL reduction are seen as an important component of the efforts of many agencies to reduce food insecurity. The following interventions are worth noting and consideration:

(i) PHL Reduction Framework

PHL is increasingly recognized as part of an integrated approach to realizing agricultures full potential to meet the worlds increasing food and energy needs. Therefore, reducing PHL along with making more effective uses of today's

crops, improving productivity on existing farmland, and sustainably bringing additional acreage into production is critical to facing the challenge of feeding and increased world population (Anonymous, 2014). The PHL strategy should be better integrated into agricultural programmes to provide technical advice and affordable solutions to farmers. The framework is best crafted to include policies, institutional frame and programme activities.

(ii) Awareness

Education on these matters in schools and political initiatives are important starting points (Wikipedia). The problem of food loss may be more complex to tackle, as it requires changes in the way we value and consume food. Our current consumption patterns are not sustainable. Food waste is effectively linked to consumer demand, which constantly evolves and is influenced by many cultural and social factors that do not always follow economic or ecological rationality. Thus, consumer awareness is a basic step to improve our abilities in food planning, purchasing and consumption. Some educational public service messages could be as such:

- (a) **Start small** – Take smaller portions at home or share large dishes at restaurants.
- (b) **Leave nothing behind** – Keep your leftovers for another meal or use them in a different dish.
- (c) **Buy only what you need** – Be smart with shopping. Make a list of what is needed and stick to it. Don't buy more than you can use.
- (d) **Don't be prejudiced** - Buy "ugly" or irregularly shaped fruits and vegetables that are just as good but look a little different.
- (e) **Check your fridge** – Store food between 1 and 5 degrees Celsius for maximum freshness and shelf-life.
- (f) **First in, first out** – Try using produce that you had bought previously and, when you stack up your fridge and cupboards, move older products to the front and place newer ones in the back.
- (g) **Understand dates** - "Use by" indicates a date by which the food is safe to be eaten, while "best before" means the food's quality is best prior to that date, but it is still safe for consumption after it. Another date mark that you can find on food packages is the "Sell by" date, which is helpful for stock rotation by manufacturers and retailers.
- (h) **Compost** – Some food waste might be unavoidable, so why not set up a compost bin!
- (i) **Donate the surplus** – Sharing is caring.

Not only that, the awareness should be compulsory for post-harvest loss handling processes. From the farmers to all the people who are directly or indirectly related to post-harvest mechanism should be aware of the efficient post-harvest processes so that the loss will be minimum.

(iii) Technology

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. There have been numerous attempts by donors, governments and technical assistance agencies over the years to reduce post-harvest losses in developing countries. Despite these efforts, losses are generally considered to remain high although, as noted, there are significant measurement difficulties. One problem is that while engineers have been successful in developing innovations in drying and storage these innovations are often not adopted by small farmers. This may be because farmers are not convinced of the benefits of using the technology. The costs may outweigh the perceived benefits and even if the benefits are significant the investment required from farmers may present them with a risk they are not prepared to take. Alternatively, the marketing chains may not reward farmers for introducing improvements. While good on-farm drying will lead to higher milling yields or reduced mycotoxin levels this means nothing to farmers unless they receive a premium for selling dry grains to traders and mills. This is often not the case.

(iv) Storage

Losses associated with the storage of plant raw materials can be reduced by using efficient storage technology, updating infrastructure and good storage practices. The World Food Programme (WFP), with the help of governments and nongovernmental organizations (NGOs), carried out operation trials in Uganda and Burkina Faso to demonstrate the impact of improved postharvest management practices and the application of new storage technologies to crop losses after harvest.

Regardless of the period of cultivation or storage, the use of improved practices and new technologies contributes to reducing the food loss by around 98% (Abedin et al. 2012). Losses in traditional storage structures are much higher, because the storage period is longer than that commonly used by farmers in these countries. It is important to understand their usefulness, technical effectiveness, and limitations in order to promote their adaptability among consumers.

Technological practices and interventions that can help reduce storage losses are chemical fumigation, natural insecticides, and hermetic storage. In addition to saving losses, the availability of cheap and effective storage structures can motivate farmers to store their cereals and obtain high prices instead of selling just after harvest, when there is a large supply of cereals (Baoua et al. 2014; De Groote et al. 2013).

(v) Capacity building

Storage structures as well as technological interventions can significantly reduce losses in warehouses, super and supermarkets, and in stores. First of all, it is important to understand that the training of service staff, not only large warehouses but also small store owners, is equally necessary as the distribution of storage technology (European Commission 2016a; Kitinoja 2013; FAO 2017b). With the provision of these technologies, government agencies and organizations must ensure the development of devices providing information and training on the use and maintenance of these technologies, in order to successfully adapt and use them effectively (European Commission 2016b; FAO, LEI 2015; Godfray et al., 2010).

(vi) Management Competence

Managerial and technical deficiencies are important causes of food losses in developing countries, especially at the harvest and post-harvest stages. Boosting investment in infrastructure and in packaging, transportation and marketing facilities is fundamental. Low prices received by farmers and lack of instruments to manage risk may discourage the adoption of technical and managerial innovations even when those are available and known.

Table 2.10 Major solution of post-harvest losses in CMCs

A. South Asia region

Country	Food	Solution/technology for post-harvest loss
Afghanistan	Cereals	▪ Reducing post-harvest losses by improving storage facilities and enhancing the technical capabilities of local tinsmiths in silo construction. The silos are hermetically sealed, thus protecting the food stored within from pests, rodents, birds and fungi. Another advantage is that of allowing produce to be kept for long periods with no loss of quality (FAO, 2009)
	Vegetables	▪ n/a
	Fruits	▪ Village level drying improvement: Clean, halve, pit, sulfur (for color preservation and mold protection), sun dry on paper on roof, package, store in cool, dry shaded room (Kuhn, Hayashi and Lea, 2006). (Added)

Bangladesh	Cereals	<ul style="list-style-type: none"> ▪ Drying: Grains should be dried in such a manner that damage to the grain is minimized and moisture levels are lower than those required to support mold growth during storage (usually below 13-15%). This is necessary to prevent further growth of fungal species that may be present on fresh grains. ▪ Threshing: For some grains, particularly millet and sorghum, threshing may be delayed for several months after harvest and the unthreshed crop stored in open cribs. In the case of maize, the grain may be stored on the cob with or without sheathing leaves for some months, or the cobs may be shelled and grain stored. (Kiaya, 2014) ▪ Winnow/Cleaning: Usually done prior to storage or marketing if the grain is to be sold directly. It is relatively ineffective from a commercial perspective, since grain purchased from smallholders frequently requires screening to remove stones, sand, and extraneous organic matter. There is little incentive for smallholders to provide well-cleaned grain for marketing; as a result profits from sales are limited ▪ On-farm storage: On-farm storage Post-harvest losses at storage are associated with both poor storage conditions and lack of storage capacity. It is important that stores be constructed in such a way as to provide: -dry, well-vented conditions allowing further drying in case of limited opportunities for complete drying prior to storage; -protection from rain and drainage of ground water; and -protection from entry of rodents and birds and minimum temperature fluctuations (Kiaya, 2014).
	Fruits & Vegetables	<p>Control of Post-Harvest Loss</p> <ul style="list-style-type: none"> ▪ Post-harvest loss in fruits and vegetables can be minimized by proper cultural operations, harvesting, transportation, storage and pre and post- harvest treatments. <p>Harvesting and field handling</p> <ul style="list-style-type: none"> ▪ Over maturity in root crops such as carrot, radish etc. causes cracking, sponginess and therefore, their harvesting should not be delayed. ▪ Harvesting of fruits and vegetables should be done at cooler parts of the day and the produce should be shifted to the packing shade as early as possible. <p>Washing and grading</p> <ul style="list-style-type: none"> ▪ Besides cleanliness, water used for washing improves the appearance of fruits and vegetables and prevents their wilting. ▪ Leafy greens such as green onion, spinach and fenugreek are tied in bundles. During washing, the organisms present on the fruits and vegetables are removed. <p>Packaging</p> <ul style="list-style-type: none"> ▪ Packaging of fresh fruits and vegetables has a great significance in reducing the wastage. Packaging also provides protection from mechanical damage, undesirable physiological changes and microbial deterioration during storage, transportation and marketing. ▪ Cheap packaging technique and materials such as polythene films, paper board boxes lined with polyethylene and other materials can effectively prolong the storage-life of fruits and vegetables. <p>Transportation</p> <ul style="list-style-type: none"> ▪ Transportation and distribution of the fruits and vegetables are the most important areas of post-harvest loss. <p>Marketing</p> <ul style="list-style-type: none"> ▪ It is very important that horticultural produce reaches the market as soon as it is possible and at a time when the market needs it the most. ▪ A perfect and efficient marketing system is essential to avoid the losses of fruits and vegetables, and also to get a good return from the same.

		<p>Controlled atmosphere storage</p> <ul style="list-style-type: none"> ▪ The controlled atmosphere storage, is one of the most significant contributions to the storage technology, and may delay softening, yellowing, quality changes, and other deteriorative processes. <p>Therefore, steps as already mentioned should be adopted, according to the suitability, and post-harvest loss of fruits and vegetables should be kept at minimum temperature. The use of appropriate chemicals at pre and post-harvest stage, may extend the availability of fruits and vegetables over a long period by protecting them from microbial as well as environmental damage. Post-harvest loss of fruits and vegetables can be considerably minimized and their storage life can be greatly increased by careful manipulation of these factors. The loss can be minimized by adopting necessary cultural operations, careful handling and packaging (Tuteja, 2017).</p> <p>For Packaging</p> <ul style="list-style-type: none"> ▪ Improved packaging such as plastic crates (stackable and nestable), woven plastic sacks, plastic net bags, and corrugated fiber board cartons should be used instead of the conventional bamboo made packages, which cause substantial damage to the produce during handling. The use of plastic crates is increasing, especially for high value produce like mango and tomato. ▪ Packages should have ventilation holes to allow aeration (5% of the surface area per side (Kitinoja and Kader 2003). <p>For Transportation</p> <ul style="list-style-type: none"> ▪ The transport vehicle should not be overloaded. ▪ Strong and durable packages should be used. ▪ Rough handling during loading and unloading should be avoided. ▪ Vibration damage would be reduced by using plastic crates, liners and padding. <p>For Storage</p> <ul style="list-style-type: none"> ▪ Produce to be stored should be harvested at proper stage of maturity. ▪ Recommended temperature and relative humidity should be maintained. ▪ The storage room should not be overloaded. ▪ Adequate ventilation in storage rooms should be ensured. ▪ The storage room should always be kept clean (Hassan, 2010).
India	Cereals	<ul style="list-style-type: none"> ▪ Based on the principle of direct evaporative cooling zero energy cool chambers have been developed. ▪ Super Grain bags are now used on a large scale by Bayer Crop Sciences for rice seed storage in India ▪ Establishment of cold chain, low cost pre-cooling facilities near farms, cold stores and grading, sorting, packing facilities to reduce wastage, improve quality and shelf life of products (National Food Processing Policy, 2017).
	Vegetables	<ul style="list-style-type: none"> ▪ The biggest challenge the industry faces is power, without which the cold chain cannot be successful. States need to invest in renewable energy and provide solar energy at subsidized rates ▪ Post-harvest handling and agro-processing and value addition technologies not only to reduce the heavy post-harvest losses but also improve quality through proper storage, packaging, handling and transport but the main challenge in to implement the technology (Kader, 2015).
	Fruits	<ul style="list-style-type: none"> ▪ The Scheme envisages the creation of support infrastructure in a well-defined agricultural and horticultural zone for setting up of modern food processing units (Government of India website).

Pakistan	Cereals	n/a
	Vegetables	<ul style="list-style-type: none"> ▪ Farmers of the area need to be trained about the harvest techniques of packaging and processing of tomato crop. ▪ Research needs to be conducted on the storage of tomato crop and farmers be informed about the results of the storage in order to avoid the losses. ▪ In order to promote horticultural industry in Pakistan, standardization of pre-harvest and post-harvest management technologies and minimizing post-harvest losses are therefore essentially required for necessary adoption to enhance foreign exchange earning to the maximum extent (Khan, 2015).
	Fruits	<ul style="list-style-type: none"> ▪ Improved access to high quality seeds (variety shelf life) and other inputs. ▪ Training of producers on appropriate use of fertilizers and pesticides, the appropriate marketing and production planning methods ▪ Improved transport practices, packaging technologies (e.g. using folding plastic boxes), improved storage infrastructures ▪ Improved access to credit and improved providing policy makers subsidies to producers ▪ Training traders on effective and efficient transport or storage practices ▪ Monitoring of mycotoxins and pesticides residues (Khan, 2015).
Nepal	Cereals	<ul style="list-style-type: none"> ▪ To reduce rodent, fungal and insect damage of stored grain including legume seeds, procuring hermetically sealed technology (HST) storage bags are very useful which are also inexpensive and prevent oxygen accumulation within the bags to prevent pests and pathogens from living. ▪ Support will be needed to minimize losses in food crops and fruits by implementing post-harvest study programs and considering established pocket package areas of agricultural food products. ▪ Therefore, need to design and to ensure development of appropriate post-harvest loss reduction technology for the hills farmers. There is an ample opportunity to reduce the storage losses of maize by improving the farmer's storage systems and through the adoption of preventive measures as an integrated package (Bandhari et al., 2015).
	Vegetables	<ul style="list-style-type: none"> ▪ Scaling up inexpensive, reusable bags for short-term storage of fruits and vegetables to prevent them from ripening, in the absence of refrigeration. The bags adsorb ethylene, a natural gas hormone produced by plants (including fruits) that would otherwise stimulate their own ripening as well as nearby plants/fruits (Kitinoja and Kader, 2015).
	Fruits	<ul style="list-style-type: none"> ▪ Improvement over the prevailing marketing functions can help in reducing post-harvest losses of the horticultural produce. ▪ Losses could be reduced by the availability of cold storage at the market centers ▪ There should be a good packaging system ▪ Over supply of products should be avoided at the market centers ▪ Grading commodities before delivery by the producers could minimize loss ▪ Careful handling and transportation facility to reduce loss of produce during marketing (A.R. Devkota et al. 2014).
Sri Lanka	Vegetables	<ul style="list-style-type: none"> ▪ Awareness of improved technology ▪ Capital to acquire improved technologies ▪ Proper marketing channels ▪ Infrastructure facilitates ▪ Testing and certification facilities ▪ PHM of fruits and vegetable ▪ Requirement of a long term Government policy to address the problems of PHM(Gedara et al., 2017).
	Fruits	<ul style="list-style-type: none"> ▪ With the objective of reducing the postharvest losses of vegetables, the government imposed a law in 2011 making it compulsory to use plastic crates to transport vegetables instead of using gunny bags. However, due to protest from farmers and traders, it was later amended, permitting the use of gunny bags for transportation of vegetables, except for those highly prone to physical damage, such as tomatoes (Gedara et al., 2017) ▪ Rice flour based deep fried cracker could be formulated with highly acceptable

		<p>sensory characteristics. Product could be stored safely for more than three months in OPP/MCPP packaging material without altering the sensory characteristics (Buwaneke, 2015).</p> <ul style="list-style-type: none"> Waxing and treatments with fungicides, heat treatments are practiced in order to increase the shelf life of fruits (Kodippili, 2016).
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B. South East Asia

Country	Food	Solution/technology for post-harvest loss
Indonesia	Cereals	<ul style="list-style-type: none"> Revitalization of small Rice Milling Unit to increase rice quality Mini combine harvester Corn Sheller machine on high moisture content The Coalition will support partner companies with strategies and practices to implement better storage technologies, improve shipping and distribution, and train staff to help them meet their food loss and waste targets (Adiandri, S.Tp., M.Si, 2017).
	Vegetables	<ul style="list-style-type: none"> Fresh handling technology of Chili Fresh handling technology of potatoes- Lighting Insulation Technology Instore Drying Technology –to reduce onion weight losses, total damage The technology promoted by companies for handling post-harvest damage or failure was the use of pesticides, especially fungicides. There is a need for improved low-tech on-farm storage solutions in combination with support on harvest, drying and treatment before shallots are stored as these steps determine the quality of the shallots that go into storage (Adiandri, S.Tp., M.Si, 2017).
	Fruits	<ul style="list-style-type: none"> Technology of Bio-Preservative Formulation (Waxing, Hot Water Treatment) Modified Atmosphere Packaging – used to pack Rambutan Instore Drying Technology –to reduce onion weight losses, total damage (Adiandri, S.Tp., M.Si, 2017).
Lao PDR	Cereals	<p>Paddy</p> <ul style="list-style-type: none"> Mechanical drying facilities for paddy Silo and storage facilities Sophisticated milling machineries Use of high efficiency mechanical thresher <p>Maize</p> <ul style="list-style-type: none"> Mechanical drying facilities to prevent 12% to 22% loss during drying process Machines for shelling Proper cleaning process to reduce 3- 10% losses Appropriate storage facilities to prevent 10-30% loss during storage
	Vegetables	<p>Cassava</p> <ul style="list-style-type: none"> Improvement in harvesting method Improved transportation especially in loading and unloading (UNIDO, 2012) <p>Common</p> <ul style="list-style-type: none"> Improved harvesting and packaging technologies Technological intervention that could extend the storage life Avoiding wet period for harvesting Preventing microbial activity to minimize disease development (Gummert, 2013)
	Fruits	<ul style="list-style-type: none"> Availability of suitable equipment and tools to support operations in the chain (Bennett, 2018) Good packaging (Bennett, 2018) Availability of, and access to collection centers, packing house facilities, transport, electricity, potable water, roads, markets (Bennett, 2018) Collection centers and pack houses need not be elaborate but must be hygienically maintained in order to minimize produce contamination Collaboration and Coordination, awareness raising, research for improvement are needed (Bennett, 2018).

Malaysia	Cereals	<ul style="list-style-type: none"> Human resources with high R&D capability are also required to conduct studies on cost-effective production of vegetables, as well as post-harvesting handling and processing with particular emphasis on agricultural mechanization, and labor-saving
		<ul style="list-style-type: none"> Food waste composting is usually implemented through two different practices, which are the in-vessel system and the windrow system (Cekmecelioglu et al., 2005; Chikae et al., 2006).
	Vegetables	<ul style="list-style-type: none"> Train workers to handle vegetables gently. If possible, harvest at the proper stage of maturity and in a dry condition. Harvest during the coolest times of the day and morning is usually recommended. Trim fingernails and/or wear cotton gloves. Minimize drop heights when transferring vegetables from baskets. Keep harvested vegetables and loaded vehicles in the shade to minimize heating(Zakaria and Roff, 2005).
	Fruits	<ul style="list-style-type: none"> Efficient and optimal utilization of existing resources in order to improve competitiveness. Quarantine protocols need to be developed for most of the export fruits to meet requirements of importing countries Development of disinfestations protocol using Hot Water Treatment (HWT) on papaya Development of disinfestations protocol using Vapor Heat Treatment (VHT) on papaya and mango(Zabeda, 2014) Development of disinfestation protocol using irradiation on papaya (Zahari, 2012)
Myanmar	Combined for cereals, fruits and vegetables	<ul style="list-style-type: none"> For small-scale food processors that lack awareness, ability and/or have unwillingness to comply with basic hygiene procedures, attention should be paid to training on GHP, GMP and HACCP principles. Vocational training on product development would address those who wish to acquire handsome skills in various aspects of food products. Vocational training would be largely directed towards those who are new to the food industry, though there may be those who are sponsored by existing food companies (NAPA, 2016) There is a need to strengthen laboratory systems by inculcating the required level of precision and/or in the laboratory to be implemented introduce a coherent system of Good Laboratory Practice (GLP). However, the laboratory operated by the FDA is considered to be generally satisfactory in terms of GLP, equipment, methods of analysis etc., although there is some need for improvements to operating procedures as well as including international and regional graduate training for laboratory staff capacity building (NAPA, 2016). In deducing principles of designing and implementing agricultural extension programs to reduce post-harvest losses, valuable lessons can be gleaned from the handful of previous extension projects and programs addressing post-harvest loss. Abstracting principles from previous experiences and using this to inform future post-harvest loss prevention programs is an evidence-based approach to arrive at solutions to this problem (McNamara and Tata, 2015).
Philippines	Cereals	<ul style="list-style-type: none"> Drying Machinery-AMDP, Recirculating Flow Dryer-UPLB ,Flatbed Dryer-IRRI, Batch Dryer-PCARRD, Multicrop Dryer-BPRE, Mobile Flash Dryer-BPRE, In-Store Dryer-PCARRD-NTA, Multicrop Solar Dyer-PCARRD, Rotary Flash Dryer,Rice Milling Machinery –UPLB, Village Ricemill-Phil,RiceMicromill-IRRI, Micromill-IRRI Portable Grain Cleaner,Shelling/Threshing Machinery –AMDP, Two-Drum Corn Sheller-BPRE are the tehcnologies that are needed for reducing postharvest losses (unapcaem.org/Activities Files/A20/10 Philippines.pdf).
	Fruits and vegetables	<ul style="list-style-type: none"> Hot water treatment - controls disease that is the biggest problem of exporters; reduced incidence of disease by as much as 70%. Modified vapor heat treatment procedure helps to restore and export mangos. Flotation technique of maturity determination defects due to immaturity is avoided (immature fruits develop internal breakdown of pulp when vapor heat treated); maturity determined with 100% efficiency compared to 20-50% of previous method.

		<ul style="list-style-type: none"> Modified atmosphere packaging (MAP) - reduce oxygen and/or increase carbon dioxide to reduce biological activity; slower ripening of banana, Solo papaya, and tomato; slower deterioration of calamansi, okra, orchids, anthurium's and roses. MAP of papaya can be used to transport papaya by sea from Mindanao to Manila prior to VHT treatment and export to Japan. Exporters of banana to the Middle East use MAP. Improved non-refrigerated van design for ships transporting fruits - one shipping line now has 300 units of a modified ventilated van for fruits (unapcaem.org/Activities Files/A20/10 Philippines.pdf).
Thailand	Cereals (rice and maize only)	<ul style="list-style-type: none"> Timely harvest Planting resistant varieties Careful handling of the produce Threshing and shelling methods should minimize damage Avoid artificial drying and control storage pest Dry produce sufficiently before storage Storage facility should be moisture proof and adequately aired (Wolf, 2012)
	Vegetables	<ul style="list-style-type: none"> Chili is the most largely produced vegetable in Thailand. In order to reduce postharvest losses of chili, handling and drying techniques have been introduced as well as standardized controls and techniques. Moreover, training workshops have been held. In 2018, improved packaging technology is planned to be promoted (Chang, 2017) Timely harvest and planting resistant varieties. Develop new equipment to have high percentage of extracting cassava roots Use hot air in wet season In the non-government sector, the Thailand Tapioca Development Institute (TTDI) is involved in cassava development. TTDI diagnoses cassava yield and emphasizes good practice of cassava plantation, e.g. by use of proper variety and production management (Wolf, 2012).
Vietnam	Fruits	<ul style="list-style-type: none"> Adoption of fresh produce handling technologies by farmers Careful handling of produce after harvest Use soft leaves or old newspapers before loading into baskets Gentle loading into appropriate containers Storing in harvested produce in cool room or storage
	Cereals	n/a
	Major	<p>Technology application:</p> <ul style="list-style-type: none"> 2007-2015: 150 inventions (Vietnam society of agricultural engineering) 2011-2015: 147 mechanization model in rice production help increasing labor productivity 10-30 times and reduce 20-25% of total production cost <p>Agricultural mechanic industry:</p> <ul style="list-style-type: none"> Tractor producing capacity: Vietnam can produce diesel machine of 30 HP; 40,000 machines/year (30% of total domestic market share)Combine harvester: Vietnam has 15 factories but only 3 factories with capacity 1,000 machines/year, Rice milling machine and Dryer. The above mentioned technological applications and agricultural machine will be helpful for reducing postharvest losses and increasing production (Dang Kim Khoi, 2017).

C. West Asia region

Country	Food	Solution/technology for post-harvest loss
Iran	Cereals	<ul style="list-style-type: none"> Preferably using fully air conditioned sorting / grading /packing facility to retain best quality at all stages. Grading, Sorting and Packing on automatic lines. Facility for mechanized packing for both Retail and Bulk. Improvement for the food processing ,capacity building, GMP,GHP practices, good packaging & R&D are needed to ensure minimum postharvest loss (Sokootifar, 2017)

	Vegetables	<ul style="list-style-type: none"> ▪ Establishment HACCP system in production chain ▪ Establishment the GHP &GMP practice in post-harvest steps ▪ Educating the labours engaged in post-harvest operations ▪ Supporting the agri-food producer (Sokootifar, 2017)
	Fruits	<ul style="list-style-type: none"> ▪ Adequate storage facilities ▪ Adequate post-harvest handling ▪ Establishment of processing clusters in some local government peripheri ▪ Appropriate method/equipment for harvesting produce(<i>Jihad-E-Agriculture Ministry, 2016</i>)

D. Pacific region

Country	Food	Solution/technology for post-harvest loss
Fiji	Vegetables	<ul style="list-style-type: none"> ▪ Helping growers gain knowledge to support better agribusiness decisions; ▪ Exploring alternative postharvest strategies by providing simple low-cost tools to do that; ▪ Using relatively high-tech equipment in a participatory learning environment to highlight relatively fundamental handling practices; and ▪ Highly targeted remediation (Kumar, 2016) ▪ By creating awareness and developing appropriate training manuals, experts in postharvest management techniques for harvesting, grading, sorting, packaging, transportation, storage (on the conventional and modern stage), processing (small and large scale) can make a significant difference in the quest to reduce losses (Faqeerzada, 2018).
	Common	<ul style="list-style-type: none"> ▪ Strengthening Research and Development (R&D) institutions ▪ Improve access to information and capacity building ▪ Improve on farm post-harvest practices ▪ Government policies revised and improvement for post-harvest loss reduction ▪ Increase investment to develop infrastructure (Kitinoja, <i>et al</i>, 2015).

Pacific region

The South Asian member countries need strategies to improve the basic issues of postharvest losses for fruits and vegetables. The development of infrastructures and proper marketing systems are very crucial. Moreover, a further important matter is to make stakeholders aware of the process of expected supply chain management and consequences of PHLs. On the other hand, the improved transport and packing arrangements are very much imperative for South East Asian member countries. There is also a need to strengthen adaptive research and technology assessment, refinement and transfer capabilities of the countries so that the existing wide technology transfer gaps are bridged.

Improvement of road transport systems, storage and packing should be done to minimize the PHLs in Iran and Fiji. There should have special care for reduction of PHLs of specialized products in these countries. The enabling policy environment must be ensured for proper growth of the modern concepts in reducing PHLs of fruits and vegetables.

The Policy Imperatives Regarding Postharvest Loss in CMCs



NO POVERTY



ZERO HUNGER



GOOD HEALTH AND WELL-BEING



RESPONSIBLE CONSUMPTION AND PRODUCTION



The Policy Imperatives Regarding Postharvest Loss in CMCs

4.1 Relevant Post-harvest policies taken by CMCs

This chapter looks at some National Policies in CIRDAP Member Countries dealing with their Post-harvest losses. These policies cover capacities of resources both human and institutional. Policies provide enabling environment to support post-harvest systems development. They further provide the guidelines to the programmes implementations.

Table 2.11 Relevant Programs and Policies of CMCs

A. South East Asia

Countries	Policies	Programmes
Afghanistan	1.1 National Wheat Program (NWP): (2016-2021) Its objectives include: providing high yield seeds instead of aging seed for better production, strengthening market elements and value chain for wheat.	1. World Food Programme (WFP)'s Purchase for Progress (P4P)
	1.2 WRAP (Waste and Resources Action Programme) (Year not specified)	2. Waste Management: Sanitation, CO ₂ Reduction, Clean Development and Recycling in Afghanistan.
	1.3 The WRI and UNEP studies (2015)	3. National Horticulture and Livestock Project (NHLP)
	1.4 National Agriculture Development Framework (NADF) (2016-2021) is a comprehensive plan for the sector and is structured around four key pillars: agricultural production and productivity, economic regeneration, natural resource management, and change management (adaptability to the weather).	1. World Environment Day (WED), which this year carries the theme "Think.Eat.Save - Reduce Your Food-print." 2. Guidance on the Prevention and Reduction of Food and Drink Waste. 3. SAVE FOOD Initiative All of the above programmes are part of the SDGs 1: No Poverty, 2: Zero Hunger, 6: Clean water & Sanitation, 7: Affordable and clean energy, 12: Sustainable Consumption & Production, 13: Climate Action, 14: Life below water, 15: Life on land & 17: Partnership for the goals.
Bangladesh	2.1 Meeting the Under-Nutrition Challenge (MUCH) 2018: it is a joint project of FAO and Food planning and Monitoring Unit (FPMU) of the Ministry of Food.	1. Agricultural Value Chain (AVC) Program
	2.2 National Agricultural Policy (NAP):(1999) Out of many one of its major policies is sustainable and profitable agricultural production through research and extension which includes reducing post-harvest losses for better production rates.	No program
	2.3 The National Food Policy (NFP) 2006 It is Bangladesh's main policy document on food security. It represents an important departure from the past by applying comprehensive and	2. A Plan of Action (2008- 2015) was developed along with 26 strategic areas of intervention and more than 300 action items were under taken in short, medium and long term over the period 2008-2015.

	integrated approach to food security, including the availability, access and utilization dimension of food security.	Objective 1: Adequate and stable supply of safe and nutritious food Objective 2: Increased purchasing power and access to food of the people Objective 3: Adequate nutrition for all individuals, especially women and children <ul style="list-style-type: none"> • undertake appropriate measures to prevent excessive losses and wastages during seasonal increase in market supply of fruits, vegetables and spices, production of which is dependent on adoption of seed varieties and harvesting technologies
India	3.1 Vision 2020: Packaging to reduce postharvest losses and increase agricultural export	1. "Operation Flood" programme which helped in converting a highly perishable commodity like milk into a commodity that can be stored over for long periods and traded across the country through a national network of storage and transportation facilities 2. Equipment developed for various post-harvest operations of field crops, vegetables and tuber crops. 3. Post-harvest technology developed for perishable commodities. Varieties suitable for processing developed in tomato and potato. On-farm storage structures, including a zero-energy cool chamber, developed for fruits and vegetables crops.
	3.2 Make in India initiative was launched by Prime Minister to transform India into a global design and manufacturing hub (2014)	1. Mega Food Park aims at providing a mechanism to link agricultural production to the market by bringing together farmers, processors and retailers 2. Cold Chain, Value Addition and Preservation Infrastructure is to provide integrated cold chain and preservation infrastructure facilities 3. Creation of processing and preservation capacities increases the level of processing 4. The Mega Food Park project is implemented by a Special Purpose Vehicle (SPV) ** (SPV) is a Body Corporate registered under the Companies Act.
	3.3 Central Sector Scheme for Setting up/ Modernization of Abattoirs (modernizing of existing abattoirs was started in the 11th Five Year Plan.) (2006)	1. 14 projects had been approved for setting up/Modernization of abattoirs as per proposals received from various State Governments/Municipal bodies. 2. Installment of grant-in-aid for the financial assistance.
	3.4 National Food Processing Policy to reduce wastage of perishables and improve the supply situation. (2014)	No program found
Pakistan	4.1 National Food Security Policy to reduce food losses along with production and supply chain including post-harvest losses (2019)	1. National Zero Hunger Programme
	4.2 Pakistan One United Nations Programme III (OP III) 2018-2022	
	4.3 Pakistan Country Strategic Plan (2018-2022)	No specific program given regarding post-harvest food waste

Sri Lanka	5.1 Sri Lanka's Country Strategic Plan (2018-2022) by WFP where progressing SDG 2 is a target.	No specific program on post-harvest food waste.
	5.2 FAO Country Programming Framework 2013-2017 Sri Lanka	1. Divi Neguma (Livelihood Upliftment) programme, Gama Neguma (Village Upliftment) programme are the programs taken to implement the policy and these programs also have some implicit positive impacts on reducing post-harvest food waste.
	5.3 Vision 2025 where Government will undertake agricultural reforms as part of many other plannings to minimize food insecurity	2. Major initiatives include a National Food Production Programme, establishing agricultural mega zones, and strengthening value chain development.
		3. Food Production National Programme 2016 – 2018 reduce post-harvest food loss by 10% Making self-sufficient and ensuring food security

A. South East Asia region

Country	Policies	Programmes
Indonesia	No policy	1. Ministry of Agriculture, The Republic Indonesia, is currently implementing a national program, called UPSUS standing for Upaya Khusus (Special Effort), and aimed at increasing productivity and production while at the same time reducing yield losses.
	No policy	2. P4G, the Partnering for Green Growth and the Global Goals Initiative led by the Food and Land Use Coalition, to build a cross-sector program to reduce food loss and waste in Indonesia by 50 percent by 2030.
	6.1 Postharvest Loss Alliance for Nutrition (PLAN) was created to bring together a multitude of public and private sector actors addressing this issue to collectively reduce loss of nutritious foods throughout the supply chain (2015).	3. A consortium of Wageningen Food & Bio based Research, the Postharvest Network, AgriProFocus, BoPInc and GAIN started a feasibility study to understand food losses in mango, shallots and tongkol fish supply chains in Indonesia (2015).
Lao PDR	7.1 Zero hunger (2011)	1. "Post-Harvest Practices" 28 March-8 April 2011 Mekong Institute, KhonKaen, Thailand By Lao Participants 2. Vegetable farmers in the Bolovens are reaching international markets (A project funded by the Common Fund for Commodities (CFC) and implemented by the Food and Agriculture Organization of the United Nations (FAO) is helping farmers in Bolovens to become competitive in the world market)
Malaysia	8.1 The New Malaysian National Agro-Food Policy; Food Security and Food Safety Issues National Agro-Food Policy (NAFP) (2012)	1. ASEAN Good Agriculture Practices (GAP) for sustainable and environmentally friendly agricultural practices, and marketing of value-added tools and food products.

	8.2 National Safe Food Network in Malaysia by FAO in 2015	<p>1. (My Save Food) programme is a programme to make better structure the Network and to measure the food loss and waste across the supply chain.</p> <p>National Save Food awareness and advocacy campaign; conducting workshops at national level to promote awareness and information sharing on food losses and waste;</p> <p>FAO is providing assistance to Malaysia to help strengthen the aquaculture biosecurity of the Department of Fisheries under a Technical Cooperation Programme (TCP)</p> <p>Malaysian Agricultural Research and Development Institute (MARDI) received a grant from FAO to develop a food loss and waste reduction project and in early 2016</p>
	8.3 Third National Agricultural Policy to enhance food security (1998 - 2010)	No specific program given under this policy
Myanmar	9.1 National Action Plan for Agriculture (NAPA).(2016) [Market-oriented Policy reforms are followed]	<p>1. Postharvest Technology Assistance Program for Myanmar Agricultural Products Project.</p> <p>2. Enhancing Food Security through Improved Post-Harvest Practice in the Dry Zone of Myanmar</p>
Nepal	10.1 Nepal: Zero Hunger Challenge National Action Plan (2016 - 2025)	<p>1. High Value Agriculture Project in Hill and Mountain Areas (HVAP) to create awareness among all stakeholders about the ways of reducing food loss/wastage</p> <p>2. High Mountain Agribusiness and Livelihoods Improvement (HIMALI) Project to train producers, storekeepers, transporters and traders for zero-loss food handling methods in storing the food crops and livestock products.</p>
	10.2 Food and Nutrition Security Plan of Action (2013)	3. Government's successful "pocket and package" programmes.
	10.3 Three Year Interim Plan FY 2014-2016 by Government of Nepal, National Planning Commission	No specific programs
Philippine	11.1 GGGI Philippines Country Planning Framework 2016-2020 where Food Security is a Strategic Priority	No specific program regarding post-harvest food waste.
	11.2 Country Programming Framework Philippines 2018 – 2024 by FAO (28 August 2018) with a view to expanding economic opportunities in agriculture, fisheries, and forestry (AFF) also reducing food insecurity.	No specific program regarding post-harvest food waste.
	11.3 Philippine Development Plan 2017-2022 by Republic of the Philippines, where expanding Economic Opportunities in Agriculture, Forestry, and Fisheries is one of the priorities.	No specific program regarding post-harvest food waste.
	11.4 Country Partnership Strategy: 2011–2016 by ADB (October, 2011)	No specific program regarding post-harvest food waste.
	11.5 The Philippine Development Plan (PDP), 2011–2016 where food security is a key PDP priority.	No specific program regarding post-harvest food waste.

Thailand	12.1 Agricultural Development Policy 11th National Economic and Social Development Plan (2012-2016) with a Vision of “Good quality of life for farmers and national food security”	No specific programs regarding this policy.
	12.2 Country Programming Framework 2012-2016	1. Food Quality Improvements along Supply Chain Appropriate post-harvest technology for small-scale fishery processing
	No specific policy	2. The National Save Food Campaign in Thailand by FAO
Vietnam	13.1 Country Programming Framework for Viet Nam 2017 – 2021 where one of the priorities is to restructure agriculture, ensure improved efficiency and stronger linkages between production and markets and also to increase food security.	1. UN One Strategic Plan (OSP) and Zero Hunger Challenge (ZHC) Initiative.
	13.2 Vietnam 2035 : Toward Prosperity, Creativity, Equity, and Democracy by the World Bank & Ministry of Planning and Investment of Vietnam where modernizing and commercializing agriculture is one of the priorities.	No specific program found.
	13.3 Viet Nam’s Socio-Economic Development Strategy for the Period of 2011-2020 by Viet Nam Government where one of the significant priorities is to ensure national food security.	No specific program found

C. West Asia region

Country	Policies	Programmes
Iran	14.1 “Vision 2025”, adopted in January 2009 by the Supreme Leader of the Islamic Republic of Iran, is the overall framework that defines long-term policy directives in all areas; projects, as a long-term goal, a society in possession of health, welfare, food security, social justice, equal opportunities, appropriate distribution of income	1. They contribute to FAO Strategic Objective H on “improved food security and better nutrition”, and to some extent also to SO D on “improved quality and safety of foods at all stages of the food chain”.
	14.2 The 5 th FYNDP (March 2011 -march2015): This development plan aims to gain self-sufficiency in food through mechanization of agricultural machinery, development of animal slaughter house and use of sustainable agriculture.	2. The GOI approve a food safety programme during the first year of the 5th FYNDP. It is expected that measures will be identified for its implementation. They may include the means to enhance health indicators in all the different stages, from farm production to the final step when food reaches the consumer’s table. It is top priority of the GOI (art. 143 of the Plan) to achieve self-sufficiency in essential agricultural crops and animal products, including wheat, barley, maize, oil seeds, sugar beet, sugar cane, poultry meat, red meat, milk, eggs, perishable goods and the improvement of consumption patterns for the Iranian population.

D. Pacific region

Country	Policies	Programmes
Fiji	15.1 <i>Fiji Agricultural Partnerships Project (FAPP)</i> : Beneficial for small scale producers in remote areas for marketing their harvests. (2015)	1. <i>IFAD</i> : Under the FAPP project, IFAD is working on building value chains, connecting producers with processors, transporters, markets etc.
	15.2 <i>Action Plan on Agricultural Commodities, Dependence and Poverty</i> (2017)	2. <i>All Agricultural Commodities Programme (AAACP) from 2007 to 2011</i> : will enhance the resilience of the F&V value chain to the vagaries that often affect small island states.

Most of the CMCs have their policies and plan of actions related to post-harvest concerns. Some policies are taken directly to address post-harvest losses and some policies are taken under food security issue where post-harvest loss reduction is an important target to accomplish with a view to ensuring food safety and security which also is emphasized on SDGs. The above mentioned policies and programs are current available policies and practices from the secondary resources. These policy and program depiction shows a genuine scenario of the current initiatives taken by the relevant ministries and responsible organizations of the CMCs.

Analysis, Recommendations and Way Forward



Analysis, Recommendations and Way Forward

5.1 ANALYSIS

Postharvest loss has been attributed to the combination of low-input production systems, poor postharvest practices, unpredictable transport, and short product shelf-life. Highly seasonal production with ensuing sporadic market over-supply and resultant prolonged storage further elevates postharvest loss. Mitigating postharvest loss within fruit value chains has become increasingly important in recent years as consumption in both developed and developing countries increased. Moreover, a shift from subsistence farming to commercial one has been duly noticed. As a result, the challenges in postharvest handling of fruits and vegetables emerge with new characteristics and dimensions.

Study shows approximately one third of the world's food is lost and demonstrated that the causes of this PHLs vary between the developed (where food waste happens predominantly at the consumer and retail end of the food chain), and the developing (where food loss is mostly a function of poor storage and marketing infrastructure) countries. The socio-economic determinants of food loss in lower, lower-middle, and middle-income countries are also to be focused. It is revealed that although GDP is positively related to food loss, investing in agricultural technologies, the transportation infrastructure and communication technologies can help reduce food loss. Overall, the results of studies show that this food loss could be eliminated by improvements in these factors. However, it is also important to note that food loss can also be influenced by many other factors such as access to regular energy supply, government policies and regulation and many others. Therefore, it is important to recognize the various drivers of food loss in detail and as location specific as possible. The studies in other locations may assist to accrue ideas on concerned issues of PHLs.

In addition, we also note that as these farm-gates and marketing problems are addressed, overall food loss may not decrease. This is because as countries grow wealthy, they shift from farm-gate "food losses" to consumer and retail "food waste". As a result, while reducing food losses may be amenable to investments in infrastructure, the shift to food waste calls for more of a sociological fix than a technological one.

In developing and indeed tropical countries, both qualitative and quantitative losses of agricultural produce occur at all stages in the postharvest chain, from harvesting, through handling, storage, processing, transportation and marketing until crops are delivered to the final consumers. Postharvest losses are more serious on perishable crops. It is estimated that, in developing countries, postharvest losses of fruits and vegetables amounts to 25-45% of the annual production. Hence, the elimination of postharvest losses of agricultural produce is very important to boost food security. In a developing country, where the standard of living of many people is very low, solutions are needed to be addressed to the problems of postharvest losses for farmers to maximize profit and make fruits and vegetable available throughout the year. It is recommended that government should provide infrastructure for the private sector to establish fruits and vegetables processing industries (Kughu et al., 2015).

In the entire marketing channel, there is insufficient facility for short and long term storage of perishables. Ideally, storage facilities should be located at each of the loading and unloading points, in the wholesale markets. This is a critical problem in the present marketing system, especially for the perishables like fruits and

vegetables. Introduction as well as establishment of cool chain is a must to reduce postharvest quantitative and nutritional losses, stabilize commodity price, reduce the negative engagement of the intermediaries, and ensure produce quality and safety. Similar observations were also reported that the infrastructures in the rural assemble; wholesale and retail markets are deficient and inadequate in developing countries. These markets are highly congested and lack basic facilities such as potable water, toilets, sewage systems, loading spaces and storage facilities. Poor market infrastructure contributes to huge losses of the high value produce. Huge quantities of wastes are generated out of processing and misuse of vegetables and fruits. Thus, appropriate policy formulation and development of mechanisms and/or establishments are duly necessary to utilize the waste towards creating wealth.

This chapter exhibits the analysis done from the literature and data collected and is of the view that, what needs to surface more prominently and addressed is the relevance of having National Food Policies that could mitigate food loss and food waste problem. Most of the CMCs have their policies and plan of actions related to postharvest concerns but varies in their extent, nature and explicitness of objectives and actions. Reviewing some of these, it appeared that Bangladesh has a practical policy. **Bangladesh launched 'The National Food Policy (NFP)' in 2006** and it is the main policy document on food security. It represents an important departure from the past by applying a comprehensive and integrated approach to food security, including the availability, access and utilization dimension of food security. The upcoming section shares the process of the Government of the People's Republic of Bangladesh developed its Plan of Action (2008-2015). Already, the government has started its new 2020-2023 Action Plan on National Agricultural Policy to address food security including food loss and food waste.

As a Plan of Action (2008- 2015) it was developed along with 26 strategic areas of intervention and more than 300 action items were undertaken in short, medium and long term over the period 2008-2015. The major objectives of it were:

- (i) Adequate and stable supply of safe and nutritious food
- (ii) Increased purchasing power and access to food of the people
- (iii) Adequate nutrition for all individuals, especially women and children

The action plan explicitly considered the postharvest matters in order to combat food loss in the total supply chain of food and food products. Some of these actions are to-

- (i) Undertake appropriate measures to prevent excessive losses and wastages during seasonal increase in market supply of fruits, vegetables and spices, production of which is dependent on adoption of seed varieties and harvesting technologies
- (ii) Provide investment assistance and training to farmers for extended use of modern post-harvest technologies for seasonal fruits, vegetables, fish and other animal products
- (iii) Expand infrastructural facilities for cleaning, grading, sorting and processing facilities involving appropriate technologies at different stages of post-harvest activities and product marketing to improve post-harvest facilities and limit post-harvest losses.

The **National Safe Food Network in Malaysia by FAO in 2015** is another relevant policy. The **My Save Food** programme is an outcome of the policy to measure the food loss and waste across the supply chain. It contributed to-

- (i) National Save Food awareness and advocacy campaign; conducting workshops at national level to promote awareness and information sharing on food losses and waste
- (ii) FAO is providing assistance to Malaysia to help strengthen the aquaculture bio-security of the Department of Fisheries under a Technical Cooperation Programme (TCP)

- (iii) Malaysian Agricultural Research and Development Institute (MARDI) received a grant from FAO to develop a food loss and waste reduction project in early 2016

FAO Country Programming Framework 2013-2017 Sri Lanka is a very significant documentation for overall livelihoods improvement through village development. And, thus, the postharvest issues of the rural production has been impacted. *Divi Neguma* (Livelihood Upliftment) programme, *Gama Neguma* (Village Upliftment) programme are the programs taken to implement the policy and these programs also have some implicit positive impacts on reducing post-harvest food waste.

What is analysed from the findings is the lack of coherence and compatible mitigating essential components and practices for conducive and enabling framework. At the end of this chapter, two different models are presented that could assist CMCs to adopt as their own Strategic Approach.

5.2 RECOMMENDATIONS

Given the positions of CIRDAP Member Countries' status in Post-harvest Losses, the report attempts to put together a practical framework as how each country could mitigate food security issues. This could be implemented through well-constructed National Policies. This is an important area missing in the literature. The policies need to be prominently addressed as enabling mechanism for the implementation of mitigating exercise to reduce food loss and food waste. The following recommendations address policy relevance, institutional frame and programme practicalities for consideration.

5.2.1 Policy relevance

- (i) Governments' policies improvement for PHL reduction:
 - (a) Support the development and adaption of applicable postharvest management technologies through well-defined policies;
 - (b) Implement and monitor postharvest management standards (safety, maturity, grading and sorting) for domestic and export markets;
 - (c) Develop contract farming and linkages among producers, processors, and traders (as PPPs);
 - (d) Make strong collaboration between producers, governments' agencies (ministry of agriculture, trade etc.), researchers and donor agencies for establishing priority projects to reduce loss in postharvest activities and manage loss properly to create wealth from it; and
 - (e) Increase public awareness campaigns to reduce postharvest losses in the consumption stages and recycle food loss to achieve food security and better environment.

5.2.2 Institutional frame

- (i) Strengthening Research and Development institutions
 - (a) Research and recommend appropriate agricultural inputs for producing quality products
 - (b) Study perishable agricultural produces within the context of its processing and market potential
 - (c) Develop farmers' friendly maturity indices and recommend appropriate harvest tools and methods
 - (d) Establish grading, sorting and packing protocols for different commodities
 - (e) Research and focus on temperature, relative humidity for different commodities under storage.
- (ii) Improve access to information and capacity building

- (a) Capacity building and working directly with farmers, traders and other value chains' stakeholders to accept and promote improved post-harvesting practices
- (b) Capacity development on proper cold chain management
- (c) Encourage simple agro-processing methods in the villages
- (d) Establish regional post-harvest management and losses reduction information networking system.
- (iii) Increase investment to develop infrastructures
 - (a) Build collection centers in the rural areas near production places and equipped with sorting, grading, packaging, sanitation and storage facilities
 - (b) Build roads from farms to collection centers, storages and market places
 - (c) Invest in the processing factories equipped with suitable processing technology, good sanitation system, suitable packaging, and appropriate food safety and quality standards
 - (d) Build market infrastructures and equipped with good storages and sanitation facilities (FAO, 2015). Additionally, modern recycle and waste management centers are to be established at strategic locations in the countries.

5.2.3 Programme practicalities

- (i) Improvement of farm post-harvest practices includes:
 - (a) Improve on-farm hygiene and packing practices
 - (b) Support small scale farmers in the basic infrastructures (packing house, cool storages) development; and
 - (c) Help producers in value adding activities.

5.3 WAY FORWARD

The problem of food loss in CMCs is caused by various factors. As way forward, Strategic Approaches are required to holistically guide the food production process to help minimize food loss and food waste.

(a) Post-harvest Loss (Food Loss and Food Waste) Reduction : Enabling Strategic Framework

This approach includes the involvement of stakeholders at three separated but interlinking levels such as policy level, institutional level and Implementation level as recommended above. This is illustrated in pictorial form below. The following recommended steps may be taken in general to better resolve the challenges of postharvest losses of produces in CMS.

- (I) Formulating policies and escalating investments to build up infrastructures for loss management of cereal, fruits and vegetables value addition.
- (II) Governments' policies improvement for PHL reduction to support the development and adaption of applicable postharvest management technologies. A congenial enabling environment is to be ensured for better postharvest handling of fruits and vegetables in the region.
- (III) Capacitating research and development institutions towards achieving standards in PHL assessment and remediation effectively
- (IV) Improving access to information and capacity building through establishing regional post-harvest management and losses reduction information networking system
- (V) Increasing investment to develop infrastructures for market and value chain development of cereals, fruits and vegetables in CMCs.
- (VI) Improving on-farm post-harvest practices to minimize loss at ground.
- (VII) Producing based on current demand of the products will lessen the amount of residuals and minimize the loss at storage.

The diagram in Figure 5 gives a pictorial illustration on how the frame works. The three levels (legislation, institutional and individual) are linked. As for monitoring and evaluation, it can be done from any level to check the practicalities. This means if the individual farmer is not happy with the way his products are being treated in any manner, relevant intervening agencies can check the institution mechanism and assist the farmer with necessary information. If there is no provision for the institution frame, then the line ministry needs to be contacted to determine what is wrong with the legislation and policy mechanism. This is clearly illustrated by the arrows. The frame also provides the pathway for responsible agencies to work in tandem. It avoids independence and isolation work of service providers. Definitely it will remove corruption to some extent when the check and balance systems are implemented.

**POST-HARVEST LOSS (FOOD LOSS AND FOOD WASTE) REDUCTION:
ENABLING STRATEGIC FRAMEWORK**

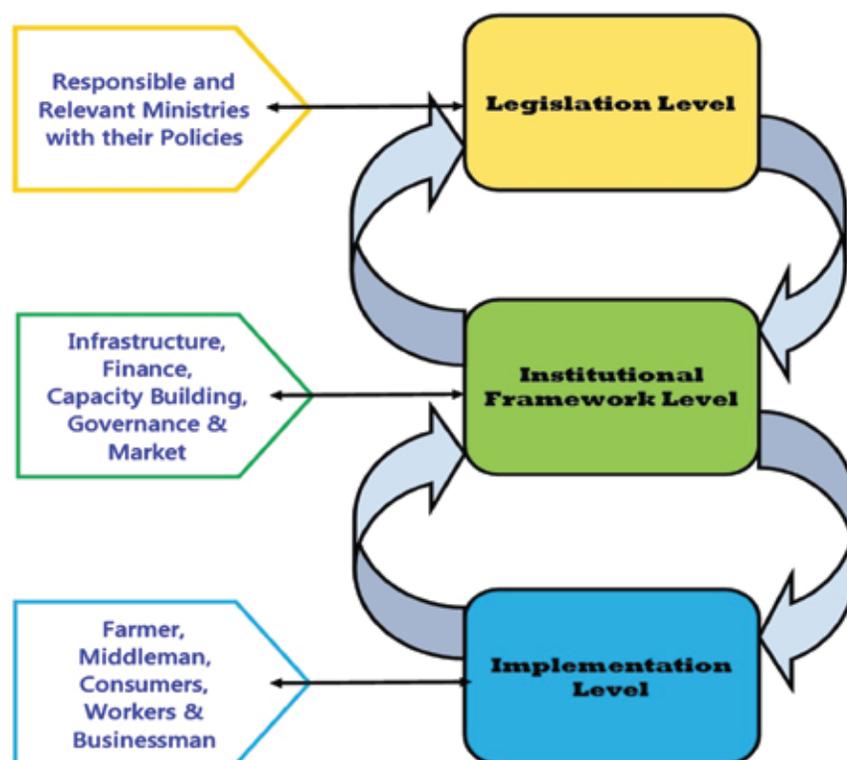


Figure 5 Post-harvest Loss Reduction Strategic Framework (CIRDAP, 2019)

The framework allows the Monitoring and Evaluation Process to take place at any level with entry similarly from any level as well. It is both clear for implementation and encompassing in its understanding for all stakeholders.

(b) Farm, Farming Environment and Input Supply

A similar framework is needed to address the process involved in food supply chain of farm produce from the farms to the markets (consumers). Food Loss and Food Wastage could be reduced, simply through the re-structuring of equitable food distribution. These are not the idle concerns they can sometimes appear to be, amidst the wasteful food culture of different nations, especially in developing countries. A solution to food waste and loss problems will have to involve consumer behavioural changes and massive shifts in procedure by primary producers, handlers, processors and retailers. A logical and achievable model of food supply system can be viewed in Figure 6.

The framework shows the following phases:

(i) Farmers grow their fruits and vegetables in their farms which is affected by the farming environment. The good production is ensured by proper management of edaphic and weather factors potentiality and essential inputs like seed, fertilizer, water, pesticides and others. Actually, the quality of the produce is started at the cultivation time which impacts the subsequent stages in the supply chain management. Thus, the production factors affect the growers, their livelihood status and total living environment. The standing of the producers finally depends on these statuses. These farmers in general harvest their

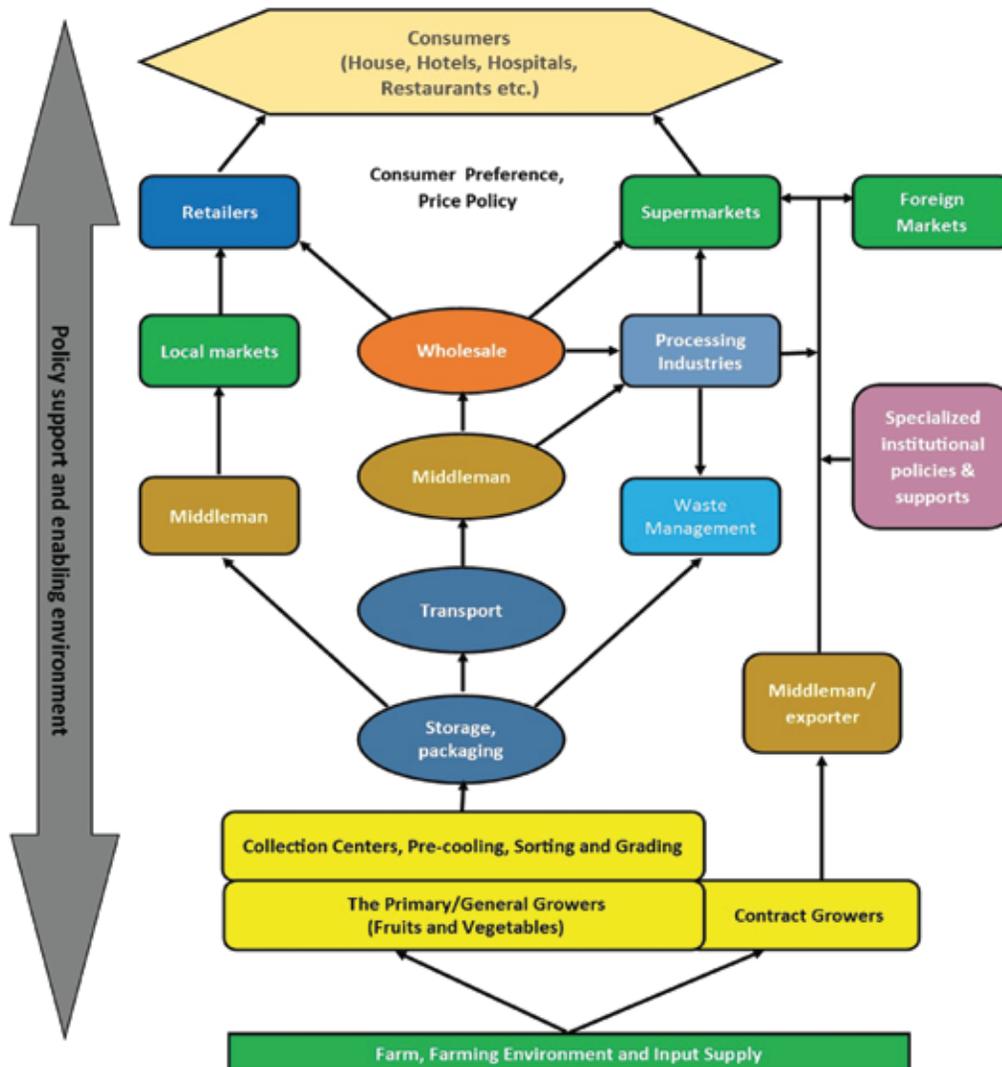


Figure 6: A suggested framework for cereals, fruits and vegetable value chain development in CMCs

produces, pile in the collection centers to dry, sort, grade and pack. This place is better to be near the plots of cultivation with minimum facilities to conduct the primary postharvest activities. After such operations, produces are either stored or enter into the transport systems for sale. The transport vehicles are to be cool (when necessary) and spacious for due aeration of the harvest. The open trucks and lorries must be covered with canvas to control the produces from scorching sun shine, rain and other precipitations.

- (ii) The middlemen then collect the produces from the collection centers or the producers themselves; sell them to wholesale markets or in local markets directly. Consumers can buy fresh produces from local markets or from the superstores in towns and cities. These stages are affected by characteristics/behaviors of the consumers, retailing policies and overall socioeconomic conditions of the country.

Another option, the produces go to processing centers for value addition. This product processing or even packaging generate substantial quantity of losses or wastes or byproducts which claim appropriate management from the stakeholders under prevailing rules and regulations.

- (iii) Apart from general growers and growing conditions of the produces, the contract growing system exists in almost all the countries. In this system, the growers come under agreements with the buyers of the produces about total production and marketing matters. The production management is guided by the buyers under specific intentions and produces are then ensured of their sale and/or marketing. Premium price is achieved in most cases for this specialized production and this is designed centering special consumers of the country. Moreover, this channel of production and value addition should maintain due standards to capture foreign markets. In maintaining standards, the specialized institution and policies of the country may support the production and value addition systems.

In spite of some socio-political, edaphic and climate difference among the CMCs, there are so many similar aspects of food production, marketing and consumption behaviors. The primary growers are major suppliers of vegetables and fruits to domestic markets. There are some contract growers to supply their produces in the local markets but is mostly done to feed the chain of foreign markets. This function is performed through a specialized arrangement supported by specific government or non-government foundations. This arrangement is duly deemed necessary as the standards of production, packaging, transport, processing (if necessary) and shipment are carefully maintained to comply with international ones. This is very urgent to boost entrepreneurial development in farming for developing nations. Development and maintenance of standard-supports to the dealers of foreign marketing are very urgent and crucial as well. The growers in general produce their cereals, fruits and vegetables chiefly for meeting demand of domestic markets. The produces are sorted, graded and packed to channelize through middlemen towards wholesale and local markets. These steps are very crucial as the transport and short-term storage are related to these. The transport system should be with a defined standard to keep the quality of produces. Then the storage should be in such standard places where the produces can be dealt in a required condition.

- (iv) The pricing policies of the region or state are to support the producers and subsequent stakeholders so that the benefit out of produces goes to all concerned duly. Moreover, the primary producers' interests should be fittingly addressed. The primary produces are to be processed to meet consumer demand and add value to produces. Maintenance of due standards is prerequisite to this processing improvements and recognition in order to keep product value and nutritional level.
- (v) The ever developing agri-entrepreneurial trend can only be kept sustainable if the controlled environments are maintained in local retailing and supermarkets in general. In order to achieve food and nutrition security in member countries of CIRDAP, the interests of the primary producers and satisfaction of the consumers must be set at top while the relevant polices are formulated and implemented. The continuous feedback of market situation and consumers' demand in interventions of value chain of vegetables and fruits must be in supply chain management researches. Finally, policy supports to create enabling environment for production improvement and establishment of appropriate distribution systems in the country. Post harvest losses reduction are less costly relating to increasing in food production in a region where land and input resources are very limited for agricultural production. Governments, technical universities, value chain's stakeholders, donors and international development agencies in countries should work together for postharvest losses reduction depicted the connection among the stages of the postharvest mechanism. The diagram below (Figure 7).

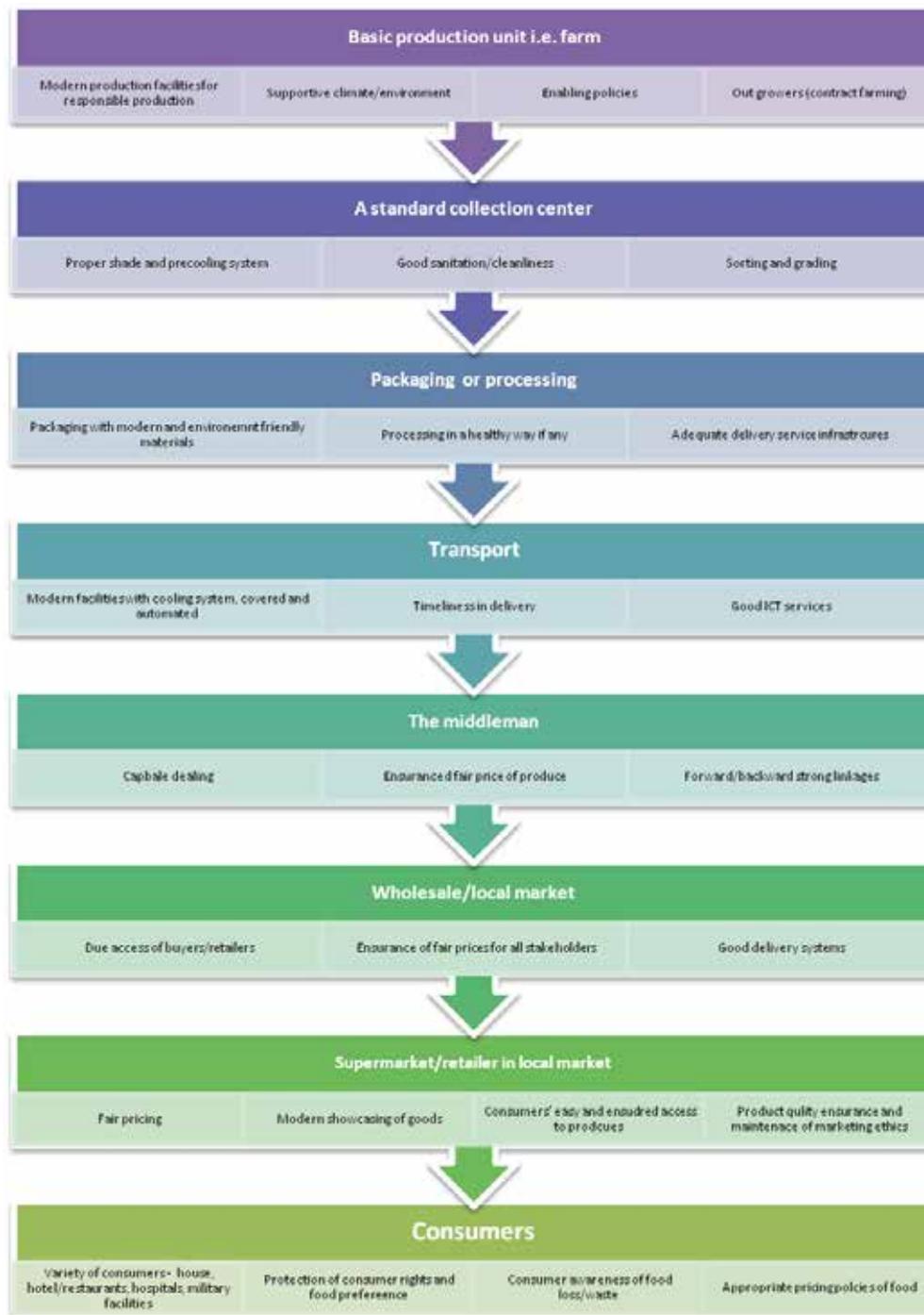


Figure 7: Processing of all the stages of post-harvest loss

CONCLUSION

In these days, interventions in PHL reduction are seen as an important component of the efforts of many agencies to reduce food insecurity. PHL is increasingly recognized as part of an integrated approach to realizing agriculture's full potential to meet the world's increasing food and energy needs to curb hunger and starvation. Therefore, reducing PHL along with making more effective uses of today's crops, improving productivity on existing farmland, and sustainably bringing additional acreage into production is critical to facing the challenge of feeding an increased world population.

Analysis of global scale food supply losses (in terms of kcal) due to lost and wasted food crops, and the amount of natural resources (freshwater, cropland, and fertilizers) that are used to produce them are of great significance in discussing PHLs and concerned issues. Studies emphasize for reducing food losses and waste, as around one quarter of the total produced food supply is lost within the food supply chain (FSC). Equally, around one quarter of the consumed water resources, cropland, and fertilizers are used to produce these losses. It is estimated that approximately half of the food supply losses, and the associated resources used to produce those, could be saved by applying everywhere the current minimum loss and waste percentages in each FSC step. If the FSC losses could indeed be halved, an extra one billion people could be fed with adequate food supply, and in addition critical resources could be preserved (Kummu et al., 2012).

Based on these considerations, the potential to reduce FSC losses is considerable, implying that reducing FSC losses could be a significant step towards a more sustainable use of the resources used in its production. The reduction of food losses and waste therefore offers possible new solutions to ease the challenges in resource scarce areas and societies suffering malnourishment. Moreover, it might bring many new entry points to technological development and innovations. Therefore, it is strongly encouraged that scientists, policy-makers, as well as producers and consumers of food, to pay more attention to reduce food losses and waste in the FSC.

These reductions could lead to a significant increase in water and food security in many parts of the world. Moreover, reducing losses would also have several important secondary benefits, such as reducing greenhouse gas emissions, conserving energy, protecting soil from degradation, and decreasing pressure for land conversion into agriculture and therefore also protecting biodiversity and carbon sinks.

Finally, in this report the SDG 1: "No Poverty"; SDG 2 "Zero Hunger"; SDG 3 "Good Health and well-being are adequately covered by showing multi-faceted way of reducing food loss and food waste. Moreover, SDG 12 "Responsible consumption and production" is highly addressed with relevant policy suggestions and recommendations for CMC s consideration in their Plan of Action to ensure food security of the future.

GLOSSARY

Causes of post-harvest losses Postharvest activities include harvesting, handling, storage, processing, packaging, transportation and marketing. Losses of agricultural produce are a major problem in the post-harvest chain. They can be caused by a wide variety of factors, ranging from growing conditions to handling at retail level. Cereals, Fruits and vegetables are perishable crops that suffer great losses both in quantity and quality after harvest. These produce require integrated approach to arrest their spoilage and overcome the present day challenges that assimilates millions of tons annually.

Food Any substance, whether processed, semi-processed or raw, which is intended for human consumption, and includes drink, chewing gum and any substance which has been used in the manufacture, preparation or treatment of "food" but does not include cosmetics or tobacco or substances used only as drugs.

Food loss it refers to a decrease in mass (dry matter) or nutritional value (quality) of food that was originally intended for human consumption. It is of any food that is lost in the supply chain between the producer and the market. These losses are mainly caused by inefficiencies in the food supply chains, such as poor infrastructure and logistics, lack of technology, insufficient skills, knowledge and management capacity of supply chain actors, and lack of access to markets. In addition, natural disasters play a role.

Food wastage Refers to any food lost by deterioration or waste. Thus, the term "wastage" encompasses both food loss and food waste.

Food waste It refers to food appropriate for human consumption being discarded, whether or not after it is kept beyond its expiry date or left to spoil. Often this is because food has spoiled but it can be for other reasons such as oversupply due to markets, or individual consumer shopping/eating habits.

Importance of proper harvest and post-harvest handling The three main objectives of applying postharvest technology to harvested cereals, fruits and vegetables are: 1) to maintain quality (appearance, texture, flavor and nutritive value) 2) to protect food safety, and 3) to reduce losses between harvest and consumption.

Post-harvest losses (PHLs) the expression "post-harvest losses" means a measurable quantitative and qualitative loss in a given product. Post-harvest losses occur between harvest and the moment of human consumption. They include on-farm losses, such as when grain is threshed, winnowed, and dried, as well as losses along the chain during transportation, storage, and processing.

Post harvesting in agriculture the post-harvest sector includes all points in the value chain from production in the field to the food being placed on a plate for consumption. In agriculture, postharvest handling is the stage of crop production immediately following harvest, including cooling, cleaning, sorting, packing, transportation and marketing. The instant a crop is removed from the ground, or separated from its parent plant, it begins to deteriorate.

Post harvesting management it includes the processes done immediately after harvesting the produce, including cooling, cleaning, sorting and packing. The instant a crop is removed from the ground, or separated from its parent plant, it begins to deteriorate.

Post-harvest operations Post-harvest handling can have a direct impact on the quality and marketability of produce, and its shelf-life, and has become a critical quality attribute in fresh produce retailing.

Post-harvest steps in postharvest activities may include harvesting, handling, storage, processing, packaging, transportation and marketing. These are some interlinked stages in post-harvest handling of cereals, fruits and vegetables. Some major steps in postharvest are defined below.

Harvesting is the process of gathering a ripe crop from the fields. Reaping is the cutting of grain or pulse for harvest, typically using a scythe, sickle, or reaper.

Postharvest handling is the stage of crop production immediately following harvest, including cooling, cleaning, sorting and packing. The instant a crop is removed from the ground, or separated from its parent plant, it begins to deteriorate.

Storage means the phase of the post-harvest system during which the products are kept in such a way as to guarantee food security other than during periods of agricultural production. It is the art of keeping the quality of agricultural materials and preventing them from deterioration for specific period of time, beyond their normal shelf life. Different crops are harvested and stored by various means depending on the end utilization.

Crop processing is a crucial step in converting raw harvested agricultural products into valuable marketable products. Processing has many facets, whether it's fine tuning processing methods for traditional crops, finding new processing approaches for traditional crops or developing new processes for new crops.

Packaging is the activity of designing and producing the container or wrapper for the product.

Transport or transportation of agricultural products is the movement of goods from one location to another. In other words, it is defined as a particular movement of an organism or thing from a point A to a Point B.

Agricultural marketing covers the services involved in moving an agricultural product from the farm to the consumer. These services involve the planning, organizing, directing and handling of agricultural produce in such a way as to satisfy farmers, intermediaries and consumers. Marketing is the final and decisive element in the post-harvest system, although it can occur at various points in the agro-food chain, particularly at some stage in processing.

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CIRDAP

The Centre on Integrated Rural Development for Asia and the Pacific (CIRDAP) is a regional, intergovernmental and autonomous institution. It was established at the initiative of the countries of the Asia-Pacific region and the Food and Agriculture Organisation (FAO) of the United Nations with support from several other UN organisations and donor countries/agencies in 1979. CIRDAP has 15 member countries which are namely Afghanistan, Bangladesh (host state), Fiji, India, Indonesia, Iran, Lao PDR, Malaysia, Myanmar, Nepal, Pakistan, Philippines, Sri Lanka, Thailand and Vietnam.

The main objectives of the CIRDAP are to: (i) assist national action, (ii) promote regional cooperation, and (iii) act as a servicing institution for its member countries for promotion of integrated rural development through research, action research, training and information, communication and dissemination.

Amelioration of rural poverty in the Asia-Pacific Region has been the prime concern of CIRDAP. The programme priorities of CIRDAP are set under four areas of concern: (1) agrarian development; (2) institutional/infrastructural development; (3) resource development including human resources and (4) employment. Within these areas of concern, the thematic areas identified are: Poverty Alleviation through participatory approaches with emphasis on social development sector (e.g. Health, education and nutrition); Employment generation through microcredit support, infrastructure development and local resource mobilisation; GO-NGO collaboration; Gender issues; Governance issues; and Environmental concerns for Sustainable Rural Development.

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