

Review Article

A Review on Post-Harvesting Losses and Opportunities in Cold Chain

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A B S T R A C T

The food supply chain is one of the most complex systems. The system begins with production and then continues with food handling techniques for preservation. In practice, the surplus food distributed seems to have been passing through various stages before it actually reaches out to consumers. However, the question arises if all the food produced is totally consumed. In this paper, we shall be studying the distinct stages involved in the food supply chain; how and where the food loss takes place; and the tremendous impacts it caused socially and economically. This paper will further help in quantifying the food waste and shall be obliged in identifying the required actions to overcome food loss and waste globally. This paper outlines different strategies and approaches adopted for post-harvest food loss assessments in order to achieve sustainable food services; move towards zero waste economy to implement poverty extermination and food security around the world.

Keywords: Cold chain, Food loss, Harvesting

Introduction

Harvesting can be termed as collection of ripened crops from the fields. Reaping is the process of cutting grains or pulses for harvest, using tools like scythes, sickles, or reapers. Today's harvesting equipment's utilizing conveyers belts replaced the manual work of harvesting by hand and

brought gentler grip and increased mass transport. The word "harvesting" is an economic principle which is known as an exit event or liquidity event. For example, if a person or business was to cash out of an ownership position in a company or eliminate their investment in a product, it is known as a harvest strategy. Harvesting consists of cleaning, sorting, packing and cooling.

Table I. Food value chain and associated losses at each stage²⁷

Production	Handling and Storage	Processing and Packaging	Distribution and Market	Consumption
Food loss while harvesting	Food lost on farm or off farm and storage	Food lost during processing, at village level or industrial level	Food lost during transportation, wholesale or retail market	Food lost at home or businesses, including in restaurants

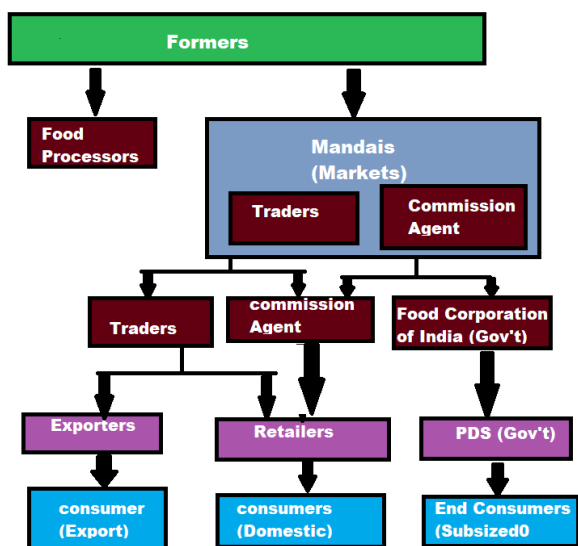


Figure 1. Structure of Agricultural Supply Chain²⁹
Post Harvesting

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. Postharvest activities include harvesting, handling, storage, preserving, processing, packing, transportation and marketing.¹ Losses of horticultural 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 managing at retail level. 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).² There are many factors affecting post-harvest losses, from the soil in which the crop was grown to the handling of produce when it reached the shop. Pre-harvest production processes do affect post-harvest outputs. Plants need a continuous supply of water for photosynthesis and transpiration. Damage can be caused by too much rain or irrigation, which can lead to decay; by too little amount of water; and by irregular water supply, which might,

for example, lead to growth cracks. Lack of plant food can affect the quality of fresh produce, causing abnormal growth or discoloration of leaves, abnormal ripening and a range of other factors. Too much fertilizer can harm the development and post-harvest condition of produce. Proper crop husbandry is necessary for reducing losses. Weeds compete with crops for nutrients and soil moisture, which will leave the crop undernourished. Decaying plant residues in the field are also a factor of loss].

For shipping of exports at minimum cost, crops are harvested early which later affects the flavors. Seasonal fruits are those that are to be harvested when ripened, but are harvested before ripening has begun. For example banana, melon, papaya and tomato. In commercial fruit marketing the rate of ripening is controlled artificially, thus enabling transport and distribution to be carefully planned. Ethylene gas is produced in most plant tissues and is important in starting off the ripening process. It can be used commercially for the ripening of climacteric fruits. However, natural ethylene produced by fruits can lead to in- storage losses. For example, ethylene destroys the green color of plants. Leafy vegetables are damaged if stored with ripening fruit. Ethylene production is increased when fruits are injured or decaying and this can cause early ripening of seasonal fruits during transport.^{3,4,5} The specific goals of post-harvest handling are keeping the product cool, to avoid moisture loss and slow down unwanted chemical changes, and avoiding physical damage such as bruising, to alter spoilage.⁶

Losses in Post Harvesting

To match efficiency with those who are more advance in economics many countries struggle and making new evolution in their agricultural supply chain. India’s population 1.2 Billion and its largest agricultural sector in world. Meaningful impact on global food security if forming out India. There are many rules and regulation including less size than 50 acres and majority farmer have 2.5 acres for farming.⁷ Due to environmental degradation and climate

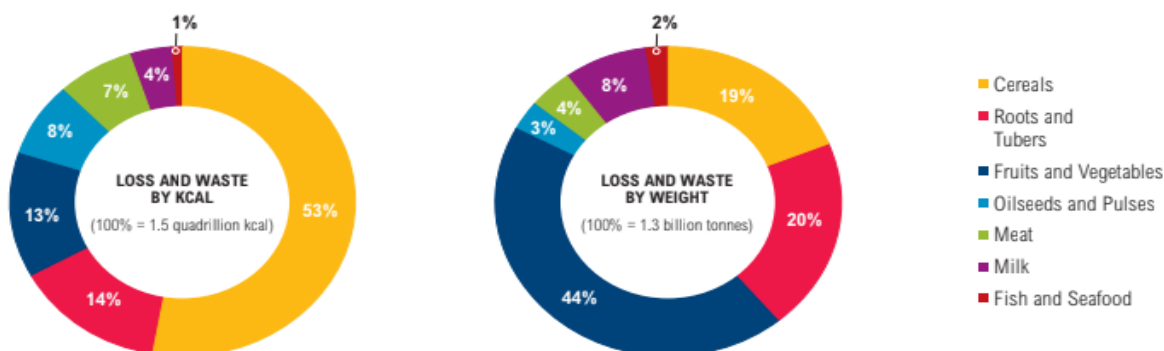


Figure 2. Share of Global Food Loss and Waste By Commodity, 2009²³

Source: WRI analysis based on FAO, 2011. Global food losses and food waste- extent, causes and prevention. Rome: UN FAO

changes the ability of world becoming invulnerable to provide safe and good food. The 1/3rd of food being lost as it is estimated by “global food loss and food waste (FAO 2011)”. Since missing food in Africa was reported by in 2011. The FAO conducted study “By Swedish Food and Biotechnology (SIK)” in terms of waste lost, which results compare to drive cereals crops the water content food such as vegetables has been bigger loss. After that WRI also find same analysis and converted SIK into calories.⁸ FAO said that 40% loss at post-harvest in developing countries and 40% loss at retail and consumer levels in developed countries [9]. \$1 trillion cost is estimated by “Global Food Loss and Waste” annually.¹⁰ Weight, volume or value is used for data collecting. To normalizing data FSC stage can clarify the scale of issue and enable comparison across organization. Influences of metric and be made you should reflect driver and purpose that organization has mattered.¹¹

Including Coffee and Cotton India is largest producer containing another 80% agriculture products. Harvesting and post harvesting have maximum loss estimating rupees 92,651 crore due to storage logistic and financial infrastructure. Dorm consumers to farmer post-harvest happen at every supply chain. Maximum food grain get wasted due to lack of exposure, illiteracy and ignorance [PDF 18]. Food loss is the main issue in combat hunger. The loss of food impact of food security for people on quality and safety and it also impacts on conditions and situation of country. In board terms food losses will be influenced by crop production choices and pattern, infrastructures and capacity, marketing chains and consumer purchasing and food use practices.¹² Around 795 million people were undernourished globally (FAO 2015) according to food agricultural organization of United Nation. As increasing population globally the pressure has come on food production. FAO estimates that 60% food should be increase to meet demand of food supply by 2050.¹³

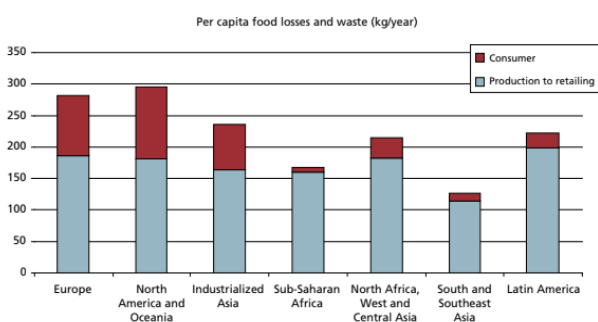


Figure 3. Per Capita Food Losses and Waste, at Consumption and Pre-consumption Stages, in Different Regions²⁵

Prevention of Post-harvest Losses

There are some preventions which can avoid post-harvest losses are classified as. To give address to the pressure of

post-harvest unsuitable food. A type of well-established technology exists that production life. And reducing FLW and enhance. The food quality and safety¹⁴ However, as discussed previously, responsibility of these application and technologies is maintain limited by markets, capital, technologies and training is less developed region.¹⁵ Thus some studies tells that developing countries may be best served by training programs to overcome FLW In Production and post-harvest handling through less wide range method.¹⁶

The postharvest management and loss prevention of food is primary adoption of farms. Women operation of winnowing, drying and storage of produced food are mainly performed by them due to illiteracy, ignorance and exposure of technology million ton of the food grains are damaged. These must have institutionalized and make part of process in every outlet. Feed people with the help of edible food. Edible food should be make available every day for free at the latest in the opening so it picked up for those in need the way of distribution by the help of food bank by making tie-ups with private actors so food can reach needy area or hunger spots feed animals. Compost the rest all food is not matching human consumption but almost matching for cattle and other animals we should be advertised by local actor

There are different types for FSC stages different category of measurement and different format's some studies used mix method and tells some example of reporting on qualitative and quantities PHLs^{17,18} The number and definition for FSC stages or VC actors starts from study to study it is difficult to camp or estimate and measurement only a few stages (i.e. farmer, trader, retailer for storage which have instruments which help for store grain and store safe). The method of PHL assessment result in quality data when methods are complex and time consuming and critical then humans neglect the steps. Asking to the farmer about production rate quantity and postharvest losses in different steps of last time we can collect the lot of data directly from farmers in few times. But the quality of production is loss or suspected those farmers remembered the quality and the market rate or value of production on harvest and threshing. Same questions which farmers can remember the value of production. What farmer can estimate or remember the quantity of lost grain at harvest or during threshing? What produces can accurately tell us the percentage or market value of these losses?

The Food Safety and Standards Authority of India (FSSAI) has steered a second round of meeting with 20 surplus food distribution agencies from various parts of the country to discuss the steps taken by government to ensure safe distribution of surplus food. FSSAI has gazette notified Food Safety and Standards (Recovery of Surplus Food)

Regulations, 2018 on 4 August 2019 to establish a uniform national regulation to protect organizations and individuals when they donate food in good faith. "This regulation will further encourage big food businesses to come forward and donate food to these surplus food distribution agencies. FSSAI has started an initiative called 'Save Food Share Food Share Joy' to create a food recovery ecosystem. This initiative aims to bridge the gap between food companies, surplus food distribution agencies and beneficiaries.¹⁹

costs. To avenge this majority of companies have aligned their Food Loss and Waste (FLW) goals with the widely adopted Sustainable Development Goal (SDG). DPSIR (Driver-Pressure-State-Impact-Response) framework is a better way of understanding the causes, impacts as well as the responses towards FLW. DPSIR states that urbanization, globalization, infrastructure investments and raising the food business causes global FLW since, it shifts food access and preferences. These trends disturbs the food supply chain.

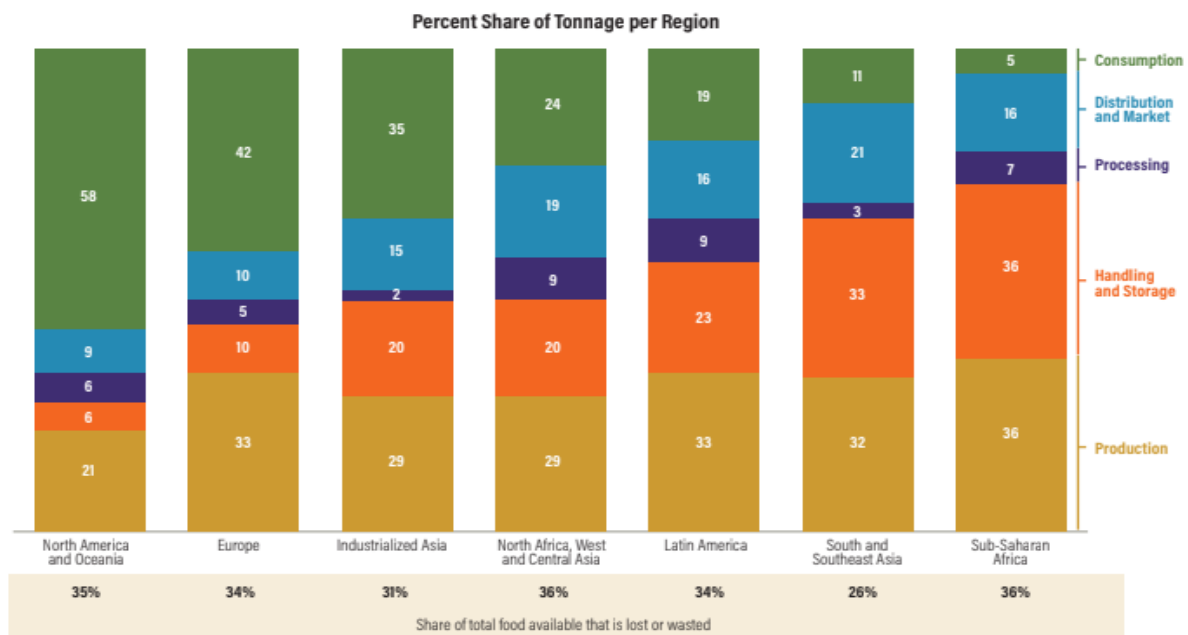


Figure 4. Distribution of Food Loss and Waste by Region and Stage in the Food Supply Chain, 2007³¹
 Source: WRI analysis based on FAO 2011.

Table 2. Food Chain¹⁹

Production	Handling and Storage	Processing And Packaging	Distribution And Market	Consumption
ICT platforms are increasingly being used to connect farmers with markets to respond more quickly to changes in supply and demand Information and communication technology (ICT) is supplying smallholders with technical information to reduce production losses.	Information and communication technology (ICT) is supplying smallholders with technical information to reduce production losses. Low-cost handling and storage technologies are gaining traction.	Technology innovations in packaging are being used to extend product shelf life. Unsold produce is being turned into upcycled products.	Apps for redistributing surplus food from retailers are growing in number Accelerator programs for food loss-reducing technologies are being established.	Retailers and food manufacturers are streamlining food date labels. Awareness raising campaigns are being launched. The hospitality sector is starting to take action

Literature Review

Vivek S. Agrawal et.al²⁰

Estimation of one-third of global food being lost or wasted has impacted the environmental, economic and social

For example loss of food at production and distribution level, as well as at retail and consumer level. Further, quantifying the FLW will help us understand the hotspots, evaluate a solution and monitor targets with the required action. This is practiced by determining the nature of waste

(e.g., whether solid or liquid), its origin, its destination as well as resources available. When coverage of FLW is taken into consideration, it was found that upstream (primary production, processing, transport, storage and wholesale) Food Supply Chain (FSC) suffer more than downstream (retail, restaurants, institutions and households) due to various assumptions made due to lack of data, direct or indirect data and outdated existing data. Mass quantities of FLW, used to find environment, economic and social impacts, can assess policy objectives, set abatement targets and help reduce FLW interventions.

Edward S. Spang et.al²¹

In 2014, as estimated in a coverage report the linkage between FLW and economic, environmental and social impacts at global scale, stated that, total environment costs as \$696 billion, total economic costs as \$1,055 billion and total social costs as \$882 billion (all in 2012 US dollars). The current and emerging options to face the challenges of FLW are planned according to Food Recovery Hierarchy- reduce, recover, recycle. Reduction includes both prevention and minimization. To enhance food quality and safety, direct pressures of post-harvest food spoilage are addressed by a well-established technologies that would extend the product life (e.g., sufficient access to cold storage, proper packaging and storing). Recovery can be summed up as collection of safe food (which would otherwise be wasted) from the places and then distribute to the needy ones. E.g., On-farm gleaning of produce left unharvested, improving of secondary markets and donation of surplus food. Recycling aims at converting FLW to recoverable material and energy just so as to avoid pollution. Recycling can be implemented by animal feeding, composting, incineration and disposal.

K Azzouz et.al²²

The thermal conductivity is not high it is sufficient to enhance the global heat transfer condition of an evaporator with air as external fluid. In this paper we studied that centimeters of slab improved refrigerator capacity. Study says approximately 10 hrs. Operation supply increases energy efficiency due evaporator enhance heat transfer. The refrigerator thermal properties of material is constant with temperature. The solidification or melting is slow and enough to calculate. The thermal resistance of evaporator and the thermal contact between resistance between evaporator and PCM are neglected. The vapour compression cycle is considered to be in the steady state. We study few centimeters of slab improved the capacity of refrigeration and also working condition without regular supply.

B Lipinski et.al²³

The food and agriculture organization of UN estimated the ration of food loss is 32 % in 2009 and FAO tries to overcome the limit of percentage up to 24 percent till year 2050. To overcome the ratio of food loss and food

waste we studied some important tasks 1) Check the food loss 2) Set food loss and wet reduction targets 3) Increase investment in reducing postharvest losses in developing countries 4) Create Entities devoted to reducing food waste in developed countries 5) Accelerate and support collaborative initiatives to reduce food loss and waste. In this paper food loss and waste refers to the edible part of plants and animals produced or harvested for human consumption. Food loss and waste apply to food product and the value chain starting from the moment. From this review paper we studied we can handle the ratio of food loss and food waste by using the guideline from the food and agriculture organization.

A Mishra et.al²⁴

Now a days energy requirements is increasing. Some of its need we can reduce by solar radiation to store that energy phase change material is very important. Due to energy requirement we need to develop some energy carrying wallet. Phase change material is key of thermal storage technology. Water (liquid) is best example of phase change material we used cooling/heating by the help of heat. We came across study of four latent heat storage system as solid to solid, solid to liquid, liquid to gas, gas to solid. These are the system we used to store solar energy in small volume with high density. Application of phase change material are electrical engines, cooking, and beverages. We studied that use of phase change materials in various fields like Buildings, Solar Water Heating System, Solar Cooker, Cooling elements, Textile, Medical application, Agricultural Green House. We can easily complete the requirement of thermal energy supply using phase change material.

Jenny Gustavsson et.al²⁵

The food is important thing for living because it is the only thing that supplies energy to body to do work. In this review paper we came through recent problems of food as food wastage and food loss ratio is increasing to overcome we need some good food handling techniques. Food losses represent waste of resource used in production such as land, water, energy and inputs. Produced food that will not be consumed leads to unnecessary CO₂ emissions in addition to loss economic value of food product. Decrease in edible food must thought the part of chain that leads to edible food for human consumption we studied some types of food losses occur as Vegetable commodities and products, Agricultural Products, Post-Harvest Handling and Storage, Processing, Distribution and consumption. This study is making a pattern of how to prevent food losses and also food wastage of animals and crops up to different stage.

Md. Imran Hossan Khan et.al²⁶

Effect of phase change material in house hold refrigeration system The Refrigeration system is now a days very

important it maintain the temperature according to our needs that's why we want to update the refrigeration system by the use of the phase change material phase change material is known as a material which is used for the cooling or heating process and it is also known as thermal storage of heat in the refrigeration system day by day changing according to need we want decide the limit of phase change material in refrigeration system Few things are important in refrigeration system are following Then again Cerri discovered the refrigeration system by the help of the phase change material then the refrigeration system improvement taken up to 12 % performance according to first invention Maltini: He discovered the Refrigeration system with the help of sodium chloride water mixtures Wang :he discovered the mathematical model which is capable of dynamic coefficient of performance by coupling phase change material Azzouz: He used the phase change material for increases the ratio Of heat transfer from the evaporator And higher evaporator maintain the cycle in off position in case of electricity Finally it is found that coefficient of performance important done up to 72% and 25% decrease the global working time of compressors Phase change material is better than other process in refrigeration system the limit of phase change material depends upon the use in which we use.

Manas Puri.²⁷

According to the latest estimates by the food and Agriculture Organization of the United Nations (FAO), around 795 million people undernourished globally (FAO). And the pressure food production will increase in following years. The Global population has crossed 7 billion mark and the requirement of food is increased by 60%, as the demand for food is increasing, which leads to increase in mass production of food. Food loss is mainly done in food chain value i.e. from agriculture production to final household consumption level. Most of the food is losses in transportation, storages etc. Modern technologies in early food supply chains is relatively low in developing countries. Due to loss of food the availability of food will be reduced, this leads to increase in prices of foods and nutritional content will also be reduced. To tackle this problem, the government should adopt improved primary production with more efficient and advanced harvesting techniques. And also adopt handling and storage technologies.

Rahul Goswami²⁸

The Food and Agriculture Organization (FAO) published a short study on 'Global Food losses and Food Waste' on May 2011. According to this report "countries which are industrialized have 40% or more food loss during post-harvest". This is more a problem for an industrialized country, and this is, mainly caused by the retailers and consumer level, as they throw the edible good stuff to

garbage. The loss of food is 120 kg/capita. The retail practices in India does not perform smooth and reliable functioning .According to resources 25% to 30% of actual fruits and vegetables and 5% to 8% of food grains are wasted in India due to lack of 'Back End' i.e. cold storage, modern market, etc. causes wastages of fruits and vegetables by 30% - 40%. To tackle this problem government has taken few points to consideration i.e. on focusing on infrastructure and supply chain method for low loss of food and also focusing on 'Back End' i.e. cold storage modern market. And also by increasing the production rate of food crops.

Paul Artich²⁹

In this review How to reduce agriculture food waste topic has been discussed with mainly 2 pts 1.agricultural supply chain, 2.problems and breakdown in supply chain thus maximum waste happen in this process. Review states that food chain supply contain 2 sector 1.private, 2 government sector with their food rates and rule regulation. Thus it get disturbed to farmer as where to supply and get max profit. Besides this transportation, infrastructure, storage is main issue for waste in chain supply. To overcome through this financial independence, export enablement and informs management and planning should be done

Lisa Kitinoja et.al³⁰

In the previous decades the issues relating food wastage has gained international concern. Somewhere climate change is also responsible for not getting proper food which is over population. Due to poor preservation methods approximately 24% of food is wasted which is supposed to reach humans to consume. We studied some food loss analysis methods. There are main two approaches as indirect measurements and sampling or direct measurement. As compared to year 2006 more efficient methods have been developed till year 2017 for analyses food losses. We came through some assessment methodology such as Commodity System Assessment Methodology (CSAM), FAO field case studies for food loss analysis, potential food loss and waste (PFLW), value chain analysis, life cycle. Assessment food wastage footprint global food loss and waste protocol (FLW protocol). We conclude on that some mixed measurement have proved better for improvement of food wastage control. Lately for the measuring PHL hybrid and combined methods are used.

Conclusion

At the last we conclude that recovering of safe food and then distributing it to wherever required is a remarkable way to deal with excess food. To achieve this various initiatives needs to be brought under consideration on global level. To limit the food waste rate, setting up of reduction targets and accelerating toward the actions for proper usage of food is an effective way. The initiatives like Annakshetra needs to be

supported with proper funding and should be encouraged for more social work. However, we as an individual too can contribute in the reduction of global food loss and waste: by utilizing and consuming the food resources in a disciplined manner. With the concluding objective of improving economic efficiency, assuring environmental sustainability and increasing food security; imperatively accelerated efforts will boost investment in food processing.

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