UNECE

Simply Measuring - Quantifying Food Loss & Waste:
UNECE food loss and waste measuring methodology for fresh produce supply chains

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1. INTRODUCTION

BACKGROUND

According to the FAO, approximately 33 per cent of all the food for consumption produced globally is either wasted or lost. This percentage amounts to a total produce weight of 1.3 billion metric tons (FAO, 2019).

Food loss and waste is no longer a negligible nuisance, it has become a sizeable and growing problem in the context of a rapidly increasing population with food and energy needs; environmental degradation, climate change, fluctuating prices and production pressures.

The reasons for food loss and waste throughout supply chains are multifaceted and occur at all nodes of the supply chain from production to consumption. They include: Shortage of access to data on production, price, requirements, storage facilities; logistic issues that arise due to freight, local transportation, including storage at destination; last-minute order cancellation; improper planning production and distribution without knowing the market demands, quality requirements; production without knowing the demands and pricing; stringent buyer requirements; rate fluctuations that impact produced goods supply and resulting in heavy food loss; "natural overproduction" due to favourable growing conditions; or climate and climate change.

While a topic with wide-reaching social, demographic and environmental impact – food loss and waste are also business opxportunities lost- engendering economic effects to all parts of the supply chain.

Therefore, the question arises of what needs to be put into place to address this complex subject towards reducing food waste and loss.

In this context and recognizing the need for and the power of data to devise, repurpose and redistribute available but currently lost food, UNECE has developed this methodology.

While a stand-alone tool, the simple UNECE methodology, which records losses and waste from production to wholesale levels, can also be integrated into an IT-based smart food loss management system to help trace and make food visible which would otherwise be lost or wasted and create opportunities to re-distribute food through or to alternative food chains. The systematic

measurement and quantification of the loss or waste by actors in the food supply chain will help the public and private sectors contribute to finding viable and sustainable solutions to the food and environmental challenges of today.

A brief introduction sets the background of the food loss and waste topic, chapter 2 shows the relevant fresh produce supply chain stages and actors that the quantification methodology is designed for. Chapter 3 includes the food loss and waste quantification method, followed by a food loss and waste hotspot analysis method in chapter 4. Chapter 5 indicates the financial loss related to the lost or wasted food. Ultimately, a food loss and waste measurement unit is suggested in chapter 6.

FOOD LOSS AND WASTE DEFINITION

According to the latest report (2019) of the Food and Agriculture Organization of the United Nations (FAO), the definitions of food loss and waste read as follows:

"**Food loss** is the decrease in the quantity or quality of food resulting from decisions and actions by food suppliers in the chain, excluding retail, food service providers and consumers." (FAO, 2019)

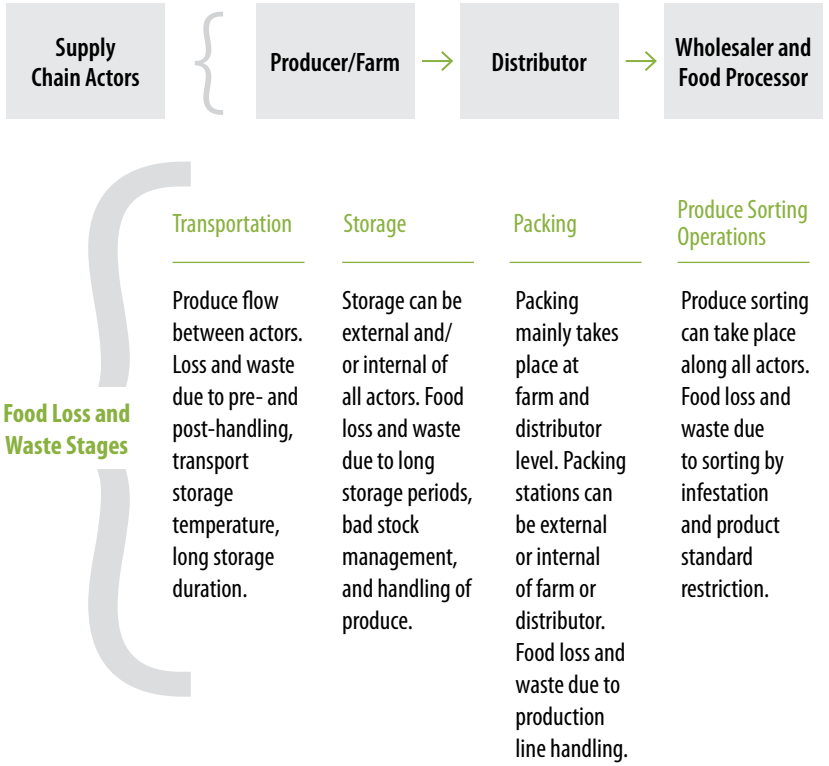
"**Food waste** is the decrease in the quantity or quality of food resulting from decisions and actions by retailers, food services and consumers." (FAO, 2019)

In line with the FAO definitions and for the purpose of this work, only food losses will be measured. However, food loss and waste may be used as a concept in some texts.

2. FRESH PRODUCE SUPPLY CHAIN STAGES AND ACTORS

For the simple food loss quantification methodology, this work solely looks at the fresh produce (fruits and vegetables) supply chain stages and actors from "production" to "wholesale" level. Essentially, it can be established that the main relevant stages and actors from production to wholesale are as shown in figure 1.

FIGURE 1
Supply Chain Actors and Waste Stages of Concern for Methodology



ACTORS:

Farms/ Harvest areas
The production level of fruits and vegetables

Distributors
Close business relationship with the farmers. The distributor is the farmer's direct point of contact for prospective buyers for the fresh produce. Nonetheless, distributors basically do not sell the fresh produce directly to the consumers.

Wholesalers
In general, wholesalers purchase large fresh produce volumes from distributors.

Food Processors
Companies that are capable to further process the fresh produce, e.g. a fresh orange juice factory. Food processors usually buy their produce from distributors as well as from wholesalers.

Packing Stations
A place where the fresh produce can be packed as desired by the various business customers. Packing stations can be at the farm or integrated in the distributor's facility as well as external in form of a third-party company that provides the packing service.

STAGES:

Transportation
Includes the fresh produce transfer between the supply chain actors.

Storage
Includes all places where the fresh produce is put into stock. Also includes the storage during transportation.

Packing
Involves the process of fresh produce packing at a packing station.

Produce Sorting Operations
Involves the process of fresh produce selection. This can be due to partial infested produce, cosmetic standard distinction, or ripening stage.

3. THE FOOD WASTE AND LOSS QUANTIFICATION METHOD

The purpose of this publication is to display a simple food loss quantification methodology for the fresh produce supply chain actors and stages from production to wholesale levels.

The formulas for quantifying lost food in the fresh produce supply chain are set on the following assumption.

- **Lost food entails removal of fruits and vegetables from the fresh produce supply chain meant for consumption by the end consumer. Therefore, it can be established:**

  Food Lost = Food Removed from the Fresh Produce Supply Chain

- **The moments of produce transitioning to a different place are the key points in the process of fresh produce trade to look at the occurrence of any amount variances.**

- **Any *processing* of fresh produce trade basically involves fresh produce packing for the intended customer at a packing house as well as any sorting operation that is undertaken. Packing and sorting operations are key points to look at lost or wasted food.**

Regarding the supply chain stages and actors of Farm/Harvest, Distributor, Wholesaler, Transportation, Storage, Packing and Sorting Operations, the following formulas are established.

(0)	X (Kg) Expected Harvest	–	X (Kg) Actually Harvested	=	Food Loss I (Kg)

> **Applicable at Harvest Level**

(1)	X (Kg) Harvested	–	X (Kg) Transported Harvest to a Next Place	=	Food Loss II (Kg)

Test formula: Food Loss II ≈ (X Kg lost through pre- and post- loading handling + X Kg lost through long storage + X Kg lost during packing + X Kg lost due to damage during transportation + X Kg lost through wrong storage temperature).

> **Applicable at Harvest Level**

(2)	X (Kg) Harvested	–	X (Kg) Out Sorted, Edible & Unsaleable Produce Due to "Standard" Restriction	=	Food Loss III (Kg)

Test formula: Food Loss III ≈ X Kg Unsalable Class II + III Fresh Produce

> **Applicable at Harvest Level**

(3)	X (Kg) Transported Produce to Storage	–	X (Kg) Received at Storage	=	Food Loss IV (Kg)

Test formula: Food Loss IV ≈ (X Kg lost through pre-and post - loading handling + X Kg lost through long transportation storage, X Kg lost through wrong storage temperature)

> **Applicable at Distributor, Wholesaler, and Food Processor Level**

(4)	X (Kg) Produce Set and Intended for Packing	–	X (Kg) Actually Packed Produce	=	Food Loss V (Kg)

Test formula: Food loss V ≈ X kg lost through produce handling at packing-production line

> **Applicable at any packing station entity**

(5)	X (Kg) Out Sorted Infested Produce (after Produce Sortation by Infestation)	=	Food Loss VI (Kg)

> **Applicable at any entity that undertakes infestation sortation**

(6)	X (Kg) Unsaleable/Not Requested Product Calibers + (Class II + III Produce)	=	Food Loss VII (Kg)

Test formula: Food Loss VII ≈ Distributor Produce Purchase % of not requested product calibers as well as class II+III produce, which the distributor is obliged to purchase.

> **Applicable for Distributors**

(7)	X (Kg) Unsaleable Produce Returned to Distributor or Farmer	=	Food Loss (Kg) (Harvest, Distributor)

> **Applicable at Harvest and Distributor Level**

4. FOOD WASTE AND LOSS HOTSPOT ANALYSIS METHOD

Food loss and waste occurs at every stage along food supply chains. However, globally there is a distinctive difference of lost and wasted food that occurs between low- and high-income countries. Contrary to low income countries - that show more food loss concentrations within the beginning of the supply chain (grower/harvest level) due to inefficient storage capabilities and lack of adequate cooling systems, bad infrastructure and transport - high income countries generate more food waste within the latter part of the supply chain (retail, consumer level). Here, the waste can result from various sources including retail (supermarkets) rejection of the produce due to quality insufficiencies, infestations such as mould etc., processing towards a product that reduced features of the initial resource, inadequate temperature conditions in warehouses or supermarkets, inadequate handling, overordering and subsequent cancellation, communication issues between involved parties, or unawareness by consumers, discarding products too soon (Gustavsson, Cederberg, & Sonesson, 2011).

To reply to the key question on where the critical waste generation points are that are related to the fresh produce supply chain stages and actors of this methodology, it can be argued that this is essentially a question of how efficient the fresh produce throughput is along all related processes. The more efficient the produce throughput of a stage, the less of a critical food loss or waste hotspot it becomes. The calculations explained in chapter 3 do not explain how efficient the throughput of the related stages is. Hence, a calculated food waste amount of e.g. 100,000 Kg can be subject to a more efficient throughput stage than a calculated food waste amount of 1,000 kg of a different throughput stage.

The ratio can be translated into a percentage when multiplied by 100 in order to show the throughput efficiency in percent. Hence, in the case of the example the "Harvest to Transportation Throughput Efficiency" is 66 %.

Hence, the calculations read as follows:

(0)	X (Kg) Actually Harvested / (Kg) Expected Harvest	(x100)	=	Harvest Yield Efficiency (%)
(1)	X (Kg) Transported Harvest / X (Kg) Harvested	(x100)	=	Harvest to Transportation Efficiency (%)
(2)	X (Kg) Out Sorted, Edible & Unsaleable Produce Due to "Standard" Restrictions / X (Kg)Harvested	(x100)	=	Produce Standard Output Efficiency (%)
(3)	X (Kg) Stored Produce / X (Kg) Transported Produce	(x100)	=	Transported to Stored Produce Efficiency (%)
(4)	X (Kg) Actually Packed Produce / X (Kg) Produce Set and Intended for Packing	(x100)	=	Produce Packing Efficiency (%)
(5)	X (Kg) Non-infested Produce / X (Kg) Produce Set for Sortation by Infestation	(x100)	=	Edible Produce Efficiency (%)
(6)	X (Kg) Saleable/ Requested Caliber Produce / X (Kg) Produce Actually Sold by One Entity to Another	(x100)	=	Successful Produce Trade Efficiency (%)

In principle, any produce throughput efficiency rate of 100% suggests a fully efficient produce throughput. The throughput efficiency rate shows the food loss or waste generation potential of the related supply chain stages.