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Sustainable Development Goal 12 and sustainable practices: food loss and food waste

Simply measuring - quantifying food loss and waste: food loss and waste measuring methodology for fresh produce supply chains *

Submitted by the secretariat

Simply measuring - quantifying food loss and waste: food loss and waste measuring methodology for fresh produce supply chains, details a food loss measuring instrument developed at the United Nations Economic Commission for Europe (UNECE). The document is presented to the Specialized Section for information and review.

This document is submitted according to ECE/CTCS/2019/10 section IV, ECE/CTCS/2019/2 Decision 2019-8.6, and A/74/6 (Sect.20) and supplementary information.

I. 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

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* Submitted on the above date to include secretariat revisions to the text.

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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 opportunities 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, it 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, section 2 shows the relevant fresh produce supply chain stages and actors that the quantification methodology is designed for. Section 3 includes the food loss and waste quantification method, followed by a food loss and waste hotspot analysis method in section 4. section 5 indicates the financial loss related to the lost or wasted food. Ultimately, a food loss and waste measurement unit is suggested in section 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 reads 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)
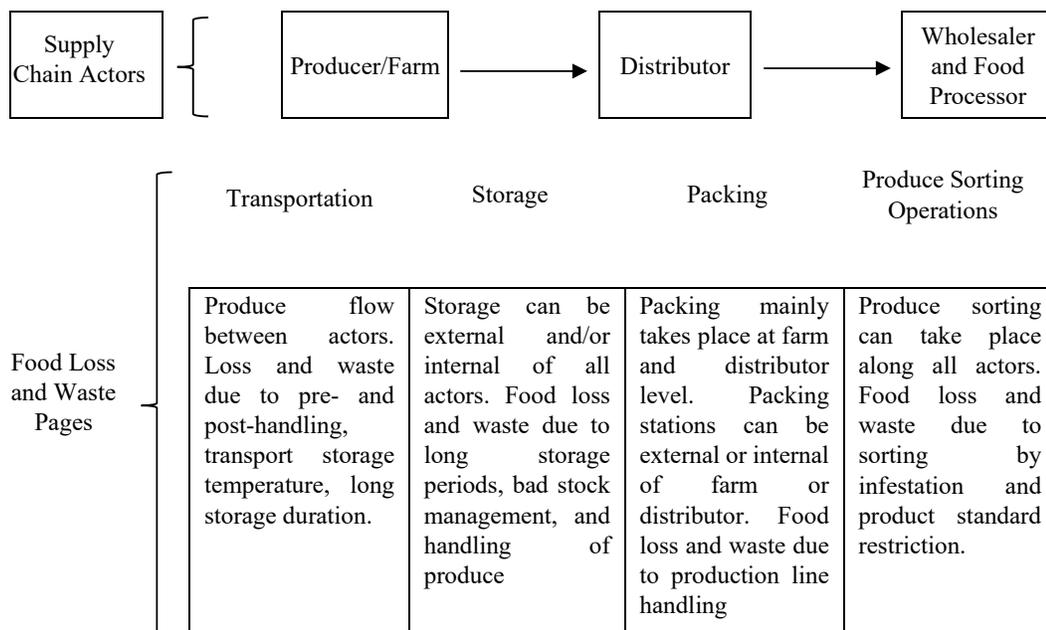
"**Food waste** is the decrease in the quantity or quality of food resulting from decisions and actions by retailers, food services and consumers."

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.

II. 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

| Supply Chain Actors | { | Producer/Farm | → | Distributor | → | Wholesaler and Food Processor |

Food Loss and Waste Pages	{	Transportation	Storage	Packing	Produce Sorting Operations
		Produce flow between actors. Loss and waste due to pre- and post-handling, transport storage temperature, long storage duration.	Storage can be external and/or internal of all actors. Food loss and waste due to long storage periods, bad stock management, and handling of produce	Packing mainly takes place at farm and distributor level. Packing stations can be external or internal of farm or distributor. Food loss and waste due to production line handling	Produce sorting can take place along all actors. Food loss and waste due to sorting by infestation and product standard restriction.

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.

III. The Food Waste and Loss Quantification Method

This purpose of this report 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**

IV. 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 – in direct comparison, 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 section 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.

Thereon based, the calculations of section 3 can be rearranged in order to show the fresh produce throughput efficiency in all cases.

For example, if 1, 500 Kg of harvest is intended for transportation but, for various reasons, 1000 Kg of produce is actually transported to the next supply chain entity, one can establish the ratio of:

$$\frac{1{,}000 \text{ Kg}}{1{,}500 \text{ Kg}} = 0{,}66 = \text{Harvest to Transportation Throughput Ratio}$$

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:

$$(0) \quad \frac{\text{X (Kg) Actually Harvested}}{\text{(Kg) Expected Harvest}} \ (\times 100) = \text{Harvest Yield Efficiency (\%)}$$

$$(1) \quad \frac{\text{X (Kg) Transported Harvest}}{\text{X (Kg) Harvested}} \ (\times 100) = \text{Harvest to Transportation Efficiency (\%)}$$

$$(2) \quad \frac{\text{X (Kg) Out Sorted, Edible \& Unsaleable Produce Due to "Standard" Restrictions}}{\text{X (Kg) Harvested}} \ (\times 100) = \text{Produce Standard Output Efficiency (\%)}$$

$$(3) \quad \frac{\text{X (Kg) Stored Produce}}{\text{X (Kg) Transported Produce}} \ (\times 100) = \text{Transported to Stored Produce Efficiency (\%)}$$

$$(4) \quad \frac{\text{X (Kg) Actually Packed Produce}}{\text{X (Kg) Produce Set and Intended for Packing}} \ (\times 100) = \text{Produce Packing Efficiency (\%)}$$

$$(5) \quad \frac{\text{X (Kg) Infested Produce}}{\text{X (Kg) Produce Set for Sortation by Infestation}} \ (\times 100) = \text{Edible Produce Efficiency (\%)}$$

$$(6) \quad \frac{\text{X (Kg) Unsaleable Produce Returned from One Entity to Another}}{\text{X (Kg) Produce Sold by One Entity to Another}} \ (\times 100) = \text{Successful Produce Trade Efficiency (\%)}$$

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.

V. Financial Loss Related to Food Loss and Waste

The financial loss related to lost or wasted food can be a topic of concern and, simultaneously, a topic of opportunities for the related supply chain actor. For a research project in 2018 of the fresh produce wastes of one leading distributor of organic fruits and vegetables considerable financial losses have been made visible as shown in table 1.

Table 1
Financial Loss Related to Lost and Wasted Food of a Dutch Fresh Produce Distributor (2015-2017)

Year	Total food lost and wasted in metric tons	Disposal costs paid in €	Lost monetary purchase value in € (millions)
2015	635.09	47,631.75	2.07
2016	1,213.28	90,996	4.3
2017	2,031.11	152,333.25	7.9

In table 1, the financial loss related to lost and wasted food can be essentially established with the help of two components.

Component I: The lost monetary purchase value (for the farm level, lost monetary sales value) of the related fresh produce. The rationale is that the entity that purchases a certain amount of produce from another supply chain actor cannot valorize what has been disposed, and therefore completely loses the amount of money that has been paid for the produce. This loss is certain as opposed to the "imaginary loss" that would occur if the produce could have been sold with a profit margin added to the purchase price (which, for instance, is the essential purpose of every produce reseller before the produce reaches the end consumer).

For the fresh produce farmer in the supply chain, a certain financial loss can be expressed through the price the distributor agreed to pay for the farmer's produce, which cannot be realized through the food that is lost.

Component II: The disposal costs that one supply chain actor must pay a disposal company. (This component may or may not be applicable for a supply chain actor depending on what the regulations on food disposal state in the specific country or area.)

Therefore, it can be established:

For Distributors, Wholesalers, and Food Processors:

Price Paid for Produce in Currency   ×   Food Lost =   Lost Monetary Purchase Value

For the harvest level:

Price Offered for Produce in Currency   ×   Food Lost =   Missed Sales Value

In both cases and if applicable with the addition of disposal service cost.

VI. Truck Unit Measurement Suggestion

In order to exemplify the data on lost and wasted fresh produce amounts, a "Truck Unit Quantification" can be used, especially for the supply chain levels downward the harvest/farm level. It is commercial practice to refer to the amount of shipped produce by talking about the number of pallets that have been transported, sold, and purchased. The dimensions and the "picture" of fully loaded pallets and trucks seem to be more comprehensible among actors of fresh produce trade as opposed to amounts only expressed in metric units. Further, a fully loaded common truck trailer seems to be more positively associated with efficient.

In fresh produce trade, the "industrial pallet" is a widely used exchange pallet throughout the world. The pallet measures a length of one meter, a width of 1.5 meters and it can be loaded with up to 1,500 kilograms for safe working (European Pallet Association, 2017). A common truck trailer can be loaded with 26 industrial pallets.

Therefore, data on lost or wasted food could be translated as shown in the example of table 2.

Table 2
Example for Truck Unit Conversion of Lost or Wasted Food Amounts

Year (or month, or period of time)	Total lost food in a common fully loaded truck
2018	1,300,000,000,000Kg / (26 pallets x 1500kg) = 33.33 Million Trucks (Annual Global Food Lost)

Hence, the conversion reads as follows:

$$\frac{X \text{ Kilogram Lost Fresh Produce}}{39,000 \text{ Kilogram}} = \text{"Fully Loaded Truck with Lost Food"}$$

Table 3
Food loss record sheet (can be used daily, weekly, or monthly)

Actor	Harvest Expected (Kg)	Harvested (Kg)	Sales Price in Currency for Harvest / Kg	Harvest Transported to Next Entity (Kg)	Out Sorted, Edible and Unsaleable Produce Due to Standard Restriction (Kg)	Transported Produce to Storage (Kg)	Received Produce at Storage (Kg)	Produce Set for Packing (Kg)	Packed Produce (Kg)	Sorted Due to Infestation (Kg)	Unsaleable/ Not Requested Product Calibres (Kg)	Unsaleable Produce Returned from One Actor to Another (Kg)	Paid Purchase Value in Currency / KG
Producer / Harvest Level													
Distributor													
Wholesaler / Food Processor													
Packing Station													
Storage													
Sorting Operation Entity													