Food Loss Reduction Toolkit CEDA

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Table of Contents

Abstract

SDG 12.3 calls for halving food waste and reducing food loss along production and supply chains by 2030. Urgent actions are needed to meet the target but lack of knowledge and data gaps hinder many organization to contribute to achieving the set goal and taking actions.
Central de Abasto of Mexico City (CEDA), the biggest wholesale food market in the world, shows leadership in this field and requested Wageningen University and Research to shade light on their food losses, hotspots, and potential of reduction.
In the absence of concrete data, providing accurate recommendations for reducing food losses becomes highly challenging. Therefore, the initial crucial step is to obtain comprehensive knowledge about the actual food losses occurring at the CEDA market, specifically in the containers. To gather reliable data regarding these losses, WUR and CEDA collaborated to create a systematic protocol. This step-by-step protocol is designed specifically for measuring the extent of food loss in the food containers present at the CEDA market. Its purpose is to ensure that the data collected is accurate and can be used as a basis for informed decision-making. The process begins by establishing certain foundational aspects, including defining food loss, determining the measurement scope, and selecting the products to be assessed. Subsequently, a four-step approach is implemented to ensure a comprehensive assessment. The first step entails the selection of waste containers that will be examined. Following this, measurements and data registration are conducted, capturing relevant information regarding the food losses. In the third step, additional data collection is performed to enhance the understanding of the situation by data analysis. Finally, the fourth step involves utilizing the collected data as a guide for evaluation purposes.
Through the implementation of two rounds of tomato and orange measurements following the comprehensive protocol, it has been discovered that the overall amount of food loss in relation to the supply to the CEDA market is significant yet relatively low. During the lean season, approximately 16 tons of tomatoes are lost per day, accounting for around 1.0% of the total supply, with a corresponding value of around 184,500 MXP/day (equivalent to approximately 10,500 US$/day). In contrast, during the peak season, approximately 3 tons/day of tomatoes are lost, which is approximately 0.3% of the supply, with a value of approximately 65,500 MXP/day (around 3,700 US$/day). Similarly, about 2.7 tons of oranges are lost daily, representing approximately 0.1% of the total supply, with an estimated value of around 1,250 US$/day. This indicates that although the losses in terms of absolute weight are significant, they are relatively insignificant when compared to the overall supply to the CEDA market.
To reduce those Food Losses WUR developed two distinct approaches for CEDA. The first approach focuses on valorisation, while the second aims to reduce the food losses within the supply chain.
Regarding valorisation, an important step involves determining the most suitable method for valorising these losses. To identify the optimal options, WUR has developed a decision tree for CEDA, which simplifies the decision-making process. This decision tree offers different routes depending on the quantity and quality and safety status of the food loss streams. It directs towards exploring applications in the realms of food, feed, biobased products, or upgrading food loss management.
To exemplify the decision tree's functionality, WUR is presents two products: tomatoes and oranges. The tomato loss stream is deemed to have insufficient quality for food or feed applications. Consequently, upgrading the food loss management through processes like biogas fermentation or potential use as feed for insects emerges as the most viable option. On the other hand, surplus or rejected oranges exhibit potential for higher-value applications, including food, feed, and non-food uses. The subsequent steps involve selecting the appropriate valorisation pathways from the proposed options. CEDA, in collaboration with entrepreneurs, can take the lead in this selection process. Furthermore, a specific business plan should be developed and evaluated accordingly. Given that the success of a valorisation pathway often relies on a consistent supply of the food loss stream, involving current suppliers in the evaluation of the plans is recommended. It is suggested to employ the decision tree approach for other food loss streams as well, extending its usefulness beyond the current context.
With regard to the second approach, reducing the food losses and economic losses within the supply chain, it is important to have a comprehensive understanding of the causes of loss in the food supply chain from the farmer to the CEDA market traders. This involves identifying the specific inefficiencies and deficiencies that contribute to food loss. Once these causes are identified, targeted interventions can be developed and implemented to address them. For example, if food is being lost due to inadequate postharvest management

like curing, storage or transportation, investments in improved postharvest processes and facilities may be necessary. Effectively tackling food loss in the food supply chain from the producers to the CEDA trades requires multi-faceted and cooperative efforts among the chain stakeholders. Together they have to discuss and implement targeted interventions to address the underlying causes of losses and waste.

In the food loss assessment of the onion supply chain, significant investment space for food loss reduction was identified. Agricultural producers stand to gain at least around 10,600 Mexican Peso (around 600 US$) per hectare, while wholesalers can potentially benefit by approximately 3,700,000 Mexican Peso (around 200,000 $ US) per year. This presents numerous opportunities for improvement, including implementing curing before bagging and loading, installing storage facilities with roofs and ventilation, providing training on harvest and post-harvest management, and encouraging traders to engage in long-term supply planning and order placement.

To take the first concrete step towards realizing these improvements, we recommend building data-driven evidence through a pilot program that demonstrates the effectiveness of the proposed intervention. To begin, the most promising supply chain for this pilot program could be a vertically integrated supply chain. Some wholesale traders are also producers or have family members supplying the produce. This would make it an interesting starting point for implementation, as they would directly benefit from the investment at the producer level. Through this strategic approach, CEDA and CEDA traders can work towards reducing food loss in the onion supply chain, while also maximizing the economic potential for all stakeholders involved.

The approaches developed and described for measuring, valorisation, and prevention of food losses in the supply chain can be expanded and applied to other food products as well, even dry products or composite products from various ingredients. These food chains may look different and have more chain links, which should then also be included in the analysis. By leveraging the same principles and strategies presented in this toolkit, other food products can also benefit from improved efficiency, reduced losses, and enhanced profitability. With the growing demand for food products, adopting an effective supply chain management approach is vital for ensuring a sustainable and reliable food supply chain. Therefore, exploring the scalability of this approach to other food products could help to address these.

Preface

By Marcela Villegas Silva, Coordinador General de la Central de Abasto (CEDA), General Coordinator of the Central de Abasto (CEDA), June 2023

Spanish
El desafío de la pérdida y desperdicio de alimentos en la Central de Abasto de la CDMX

En 2022, celebramos los cuarenta años de operaciones ininterrumpidas de la Central de Abasto de la Ciudad de México, cumpliendo con la misión estratégica de procurar el abasto suficiente, oportuno y en las mejores condiciones de higiene, de productos alimenticios a los habitantes del Valle de México y parte de la República Mexicana, mediante la modernización de su infraestructura y la regulación del flujo de productos, en beneficio de productores, comerciantes y consumidores.

Dentro de los festejos hubo importantes reflexiones de los desafíos que enfrenta nuestro mercado mayorista, su impacto urbano y ambiental, por los recursos que se utilizan en su operación tales como: consumo de agua y energía eléctrica, uso de combustibles y generación de residuos.

Por lo anterior, la CEDA ha puesto en marcha una serie de iniciativas, en conjunto con la Organización de las Naciones Unidas para la Alimentación y la Agricultura (FAO) y distintas dependencias gubernamentales y educativas. En noviembre de 2021, se dieron los primeros acercamientos con la Embajada del Reino de los Países Bajos en México y el Grupo de Investigadores de la Universidad y Centro de Investigación de Wageningen (WUR), con el objetivo de buscar la transición a la economía circular para promover el aprovechamiento complejo de nuestros recursos en el tema específico de reducción de la pérdida y desperdicio de alimento.

En enero de 2022, comenzamos este ambicioso proyecto que tiene como principal reto contribuir con el Objetivo 12.3 del Desarrollo Sostenible de la Agenda 2030 “Reducir a la mitad el desperdicio de alimentos per cápita mundial en la venta al por menor y a nivel de los consumidores y reducir las pérdidas de alimentos en las cadenas de producción y suministro, incluidas las pérdidas posteriores a la cosecha”.

En esta presente contribución, respecto del desperdicio de alimento en la CEDA, el estudio proporciona claridad ante los supuestos previos; si bien el volumen del desperdicio del tomate y de la naranja es alto, éste comparado con el volumen que se comercializa diariamente, es bajo, por lo que, la valorización de ambos productos resulta una acción más pertinente en comparación con las acciones enfocadas a reducir el desperdicio.

Aquí se documentan las herramientas y los conocimientos necesarios que se desarrollaron a lo largo de un año y 3 meses de trabajo bajo el enfoque objetivo – medida - acción. Se presta especial atención en los datos resultado de las mediciones en los contenedores de residuos de la Central de Abasto, en los productos mencionados arriba; en el caso de la cadena de suministro de la cebolla, se identificaron los de puntos conflictivos (productos y etapas de la cadena), y la designación de intervenciones con impacto. La Central de Abasto trabaja con las partes interesadas para lograr acuerdos voluntarios sobre la reducción de la pérdida y la valorización del desperdicio de alimentos.

Es la primera ocasión en la historia de la CEDA, que se cuantifican los residuos, haciendo una caracterización de los mismos; si bien se documentó que nuestro porcentaje es bajo, alrededor del 2%, es factible teniendo como modelo de producción y consumo a la economía circular, ser un mercado mayorista más sostenible, limpio y con menos desperdicios. Con ayuda de los académicos, los comerciantes y usuarios asumimos el compromiso de cada vez más disminuir nuestra huella ecológica, por nuestro bienestar económico, y por la sobrevivencia de la humanidad como una especie que habita este planeta.

English
The challenge of food loss and waste in the Centro de Abasto of the CDMX

In 2022, we celebrated forty years of uninterrupted operations of the Centro de Abasto of Mexico City (CEDA), fulfilling its strategic mission of ensuring a sufficient, timely, and hygienic supply of food products to the inhabitants of the Valley of Mexico and part of the Mexican Republic. We have achieved this by modernizing its infrastructure and regulating the flow of products for the benefit of producers, traders, and consumers.

The celebrations included important reflections on the challenges facing our wholesale market, its urban and environmental impact, and the resources used in its operation, such as water and electricity consumption, fuel use, and waste generation.

Therefore, CEDA has launched a series of initiatives in conjunction with the Food and Agriculture Organization of the United Nations (FAO), and various governmental and educational agencies. In November 2021, the first approaches were made with the Embassy of the Kingdom of the Netherlands in Mexico and the Group of Researchers of the Wageningen University and Research Centre (WUR), with the aim of seeking the transition to the circular economy to promote the complex use of our resources in the specific issue of reducing food loss and waste.

In January 2022, we started this ambitious project, whose main challenge is to contribute to Sustainable Development Goal 12.3 of the 2030 Agenda "Halve global per capita food waste at retail and consumer level and reduce food losses in production and supply chains, including post-harvest losses".

In this contribution regarding food waste in the CEDA, the study provides clarity to the previous assumptions. Although the volume of tomato and orange waste is high —compared to the volume that is marketed daily— it is overall low, so that the valuation of both products is a more relevant action compared to the actions focused on reducing waste.

Here, we document the necessary tools and knowledge that were developed over fifteen-month period of work under the objective-measure-action approach. Special attention was paid to the data resulting from measurements in the Centro de Abasto's waste containers for the products mentioned above. In the case of the onion supply chain, the hotspots (products and stages of the chain) were identified, and interventions that would result in significant impact were noted. The Centro de Abasto is working with relevant stakeholders to reach voluntary agreements on reducing food waste, loss, and recovery.

This is the first time in the history of the CEDA that waste has been quantified and characterized. Although it was documented that our waste percentage is low (at around 2%). The goal of a more sustainable, cleaner, and less wasteful wholesale market is achievable by using a production and consumption model of the circular economy. With the help of academics, merchants, and users, we assume the commitment to increasingly reduce our ecological footprint to protect our economic well-being and for the survival of humanity as a species in this planet.

Acknowledgments

The Food Loss Toolkit was developed through a collaborative effort that included a multitude of organizations and individuals, in addition to the authors. Their contributions and support were essential in bringing this project to fruition. Without their involvement, this initiative would not have been possible. Firstly, we would like to thank the CEDA team headed by Marcela Villegas Silva and Area Coordinators/Directors: Juan Pablo Espejel, Graciela de Paz and París Alanis; and especially Luis Alberto Hernandez Pérez, Martha Jarquín Sánchez, Diana Ivette González Cedillo, for the valuable collaboration and data collection which was instrumental in shaping the content and scope of the FL toolkit; to the merchants (traders) for let us familiarize with wholesale market operation. We also would like to thank the FAO experts Lina Pohl Alfaro, Karina Sanchez Bazan and other FAO experts who shared their insights and experiences in the field of food loss and were part of the consultative group of the project. Special thanks go to The Netherlands Embassy in Mexico City Erik Plaisier and Frank Hoogendoorn and the Ministry of Agriculture, Nature and Food Quality (LNV) Vera Musch and Jeanet Smids-Goosen for the provision of the funds and guidance for this project. We are grateful for the broad involvement and commitment to the development of the toolkit.

1. Introduction

In Low- and Middle-Income Countries (LMIC) wet food markets have a considerable market share. Especially for fresh food products consumers commonly rely on them. However, in terms of volume these markets are major generators of food loss. But also the supply chains towards wholesale markets contribute to food loss significantly. This research developed tools to reduce food losses or generate value from the current residual flows or side streams that now lead to food losses. The toolkit contains guidance, templates, and examples for taking the following steps in addressing food loss:

1. Measuring food loss at specific loss hotspots (wet markets).
2. Deciding on the appropriate valorisation route for selected side streams.
3. Identification of food loss causes and interventions along the (postharvest) supply chain.

This toolkit contains tools and necessary knowledge, contributing to the goal of halving food loss at CEDA by 2030 and reducing food loss along production and supply chains. Special attention is paid to establishing baseline data, the identification of hotspots (products and chain stages), and appointing impactful interventions. The guides and templates in this toolkit can be easily implemented and adapted to scale up action towards zero-waste.

1.1. The problem

Central de Abasto of Mexico City (CEDA) is the biggest wholesale food market in the world. It offers a business place for approximately 10,000 businesses and is the main source of fresh food supply in Mexico City, the Metropolitan Area, and various regions of the country. However, at the same time CEDA faces pressure and challenges in the handling of food. It is estimated that CEDA generates an average of 392 tons of food loss per day. Throughout 2021, it was estimated that as much as 107,000 tons of food loss was generated. Although the absolute value of food loss is high, it is not known from a relative point of view, which is necessary to give a balanced judgement about it and considered essential for deciding about further steps. This project was initiated in order to identify possible solutions pathways.

1.2. Definition of Food Loss and Waste

Before elaborating about the project, it is important to introduce definitions on food loss and waste (FLW). Currently, there is no worldwide consensus about the definition of food waste. For instance, in the EU only the term 'food waste' is used [1], whereas FAO and SDG 12.3 split up the food residual flows in 'food loss' and 'food waste'. SDG 12.3 is targeting all countries in the world and hence for Mexico the definition of FAO and SDG 12.3 is applied [2]:

Food Loss and Waste (FLW) definition

FLW refers to all food intended for human consumption that is finally not consumed by humans. Food Loss is the decrease in the quantity or quality of food resulting from decisions and actions by food suppliers from the production stage in the chain, excluding retail, food service providers and consumers. Food Waste is the decrease in the quantity or quality of food resulting from decisions and actions by retailers, food services and consumers. Under this definition, FLW does not include food that is consumed in excess of nutritional requirements nor food that incurs a decrease of market value due to over-supply or other market forces, and not due to reduced quality.

Remark: The word *waste* is used if it is or <u>can</u> be something else than food.

According to this definition, the emphasis of this work is therefore not on Food Waste, but entirely on measuring, valorising and reducing Food Loss. As a result, this document will use the term 'food loss' throughout.

1.3. General information CEDA

On November 22, 1982, the Central de Abasto was inaugurated by the President of the Republic José López Portillo and the Regent of the Federal District, Carlos Hank González. It exists for 40 years now. The area of the market is 327 ha and 90,000 people serve half a million clients every day [3].There are 9,737 economic entities at CEDA of which the following are sales locations:

Table 1 Sales locations per category.

Horticultural category of sales location	Number of sales locations in CEDA
Groceries	897
Poultry and meat	167
Fruits and vegetables	4,364
Flowers and vegetables	3,387
Total	**8,815**

The other 922 locations are for services. The categories are linked to areas in the market as is shown in Figure 1.

Figure 1 Map of CEDA (source: CEDA).

CEDA is a huge marketplace where (per product) aggregated flows from many different farmers arrive. Due to the different climatic conditions in Mexico, CEDA gets year round freshly harvest products supplied throughout the entire year. However, supply comes from different areas and different producers. Although some traders at the market are also producers, in general, the producers do not know the buyers at CEDA. The focus of the traders is on buying volumes at the lowest possible price rather than on quality and selling as soon as possible (normally within 1-3 days) for the best price. Storage of products by the traders under controlled conditions is the exception. It needs additional space, currently not available at CEDA, and adds costs which can only be recouped in particular cases. In general, it takes one to three days from the harvested area to the CEDA the market. Producers are normally professional growers, also delivering products directly into high end markets like the US. The transportation to CEDA normally takes place under ambient conditions. Sometimes products are transported in bulk, sometimes packed in boxes. The quality of the product can vary (shelf life, ripeness, size, colour, and so on). Selection and cleaning fruit often takes place at the market itself.

1.4. Food loss reduction and valorisation strategy for CEDA market

In order to develop insight in the food loss streams, and to identify promising interventions, for CEDA the following strategy is applied (Figure 2).

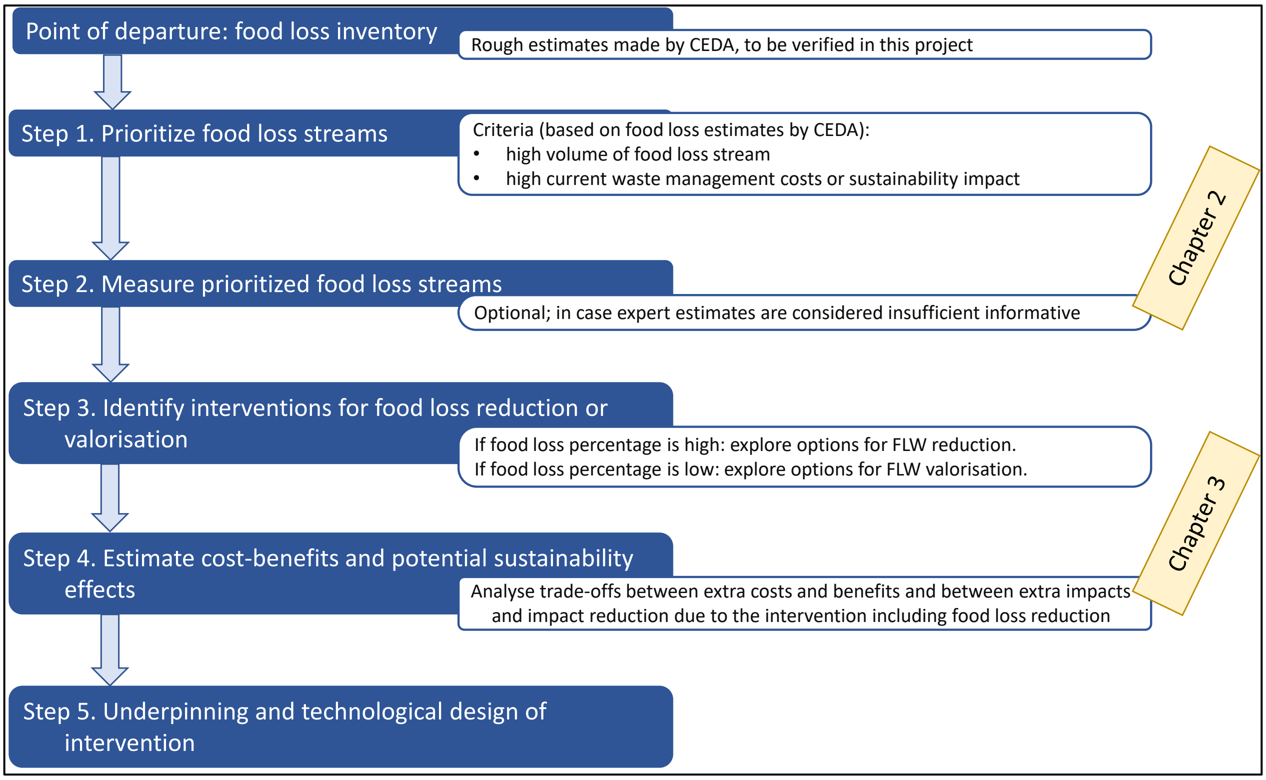


***Figure 2** Strategy for food loss reduction and valorisation at CEDA.*

The exploration of interventions (step 3) can be either aimed at reduction or valorisation of the food loss streams. For reasons of effectiveness, interventions oriented on loss reduction (like introduction of cold chain, packaging, etc) should be broadly applied for all products. In case the actual loss percentage is low, introducing the intervention to all products may be more expensive (also in terms of sustainability impact) than the (small) benefit of loss reduction, even if the loss volume is substantial. In such situations food loss valorisation is more obvious than food loss reduction. In case the percentage of food loss as well as the actual volume are high, food loss reduction is considered most sustainable (since it keeps the food products available as food), but in specific situations food loss valorisation may still be more adequate (either for economic, logistic, quality, or technological reason).

In assessing cost-benefits and sustainability effects (step 4), trade-offs between the extra costs and impacts due to the intervention and savings due to food loss reduction must be estimated. Most food loss-reducing interventions add extra environmental sustainability impact. On the other hand, through reducing the food loss, less crops are required to fulfil the demand. The net effect can be estimated through the ACE calculator[1]. A food loss valorisation intervention diverts the food loss stream from a waste destination (often with large environmental sustainability impact) to a valuable product, which replaces another virgin feedstock. Commonly this strongly contributes to reducing environmental sustainability impacts; this can also be estimated through for example the ACE calculator.

The steps were implemented for CEDA at two levels: the wet market of CEDA and at the level of supply chains from farm to CEDA.

[1] Available through https://www.wur.nl/nl/project/A-new-approach-towards-Food-Loss-and-Waste-including-Greenhouse-Gas-Emissions.htm

The strategy for CEDA is based on a food loss inventory by CEDA before the start of the project. Based on that, 5 fruits and vegetables streams were chosen (step 1) as first priorities for measurements. To find out the percentage of food loss at CEDA (step 2) a protocol was developed for CEDA (Chapter 2). Attention is paid to establishing baseline data for food loss of two products on the wholesale market.

Since the CEDA market authorities can influence the management of food loss generated at the market, opportunities for higher value valorisation of selected streams are further explored in Chapter 3 (step 3). Dedicated products that can be prevented from wasting may be destined for food or feed application. But, once the food loss is in the waste container, options are limited due to the poor and poorly controlled quality and safety status. Then, only processing that is not critical on quality is possible, most commonly waste treatments. A number of methods for upgrading the waste treatment (and that still generate valuable products, thereby also contributing to minimizing environmental impact, like greenhouse gas emissions) are proposed. A pathway to check the valorisation options is presented in Chapter 3, including some cases related to the food loss flows researched in this project (step 4). In this context CEDA introduced small-scale initiatives like food donations, anaerobic bio digestion and biodiesel production. These destinations generate higher value than the recently embraced reference organic food loss management option: composting.

To put food loss at CEDA in perspective, and to judge the relevancy of food loss-interventions at and beyond CEDA, a methodology was developed and applied to analyse the food loss along value chains to CEDA (Chapter 4). Based on cause analysis of hotspot food loss streams, interventions for food loss reductions are identified and prioritized on relevant criteria. The onion value chain is elaborated as an example.

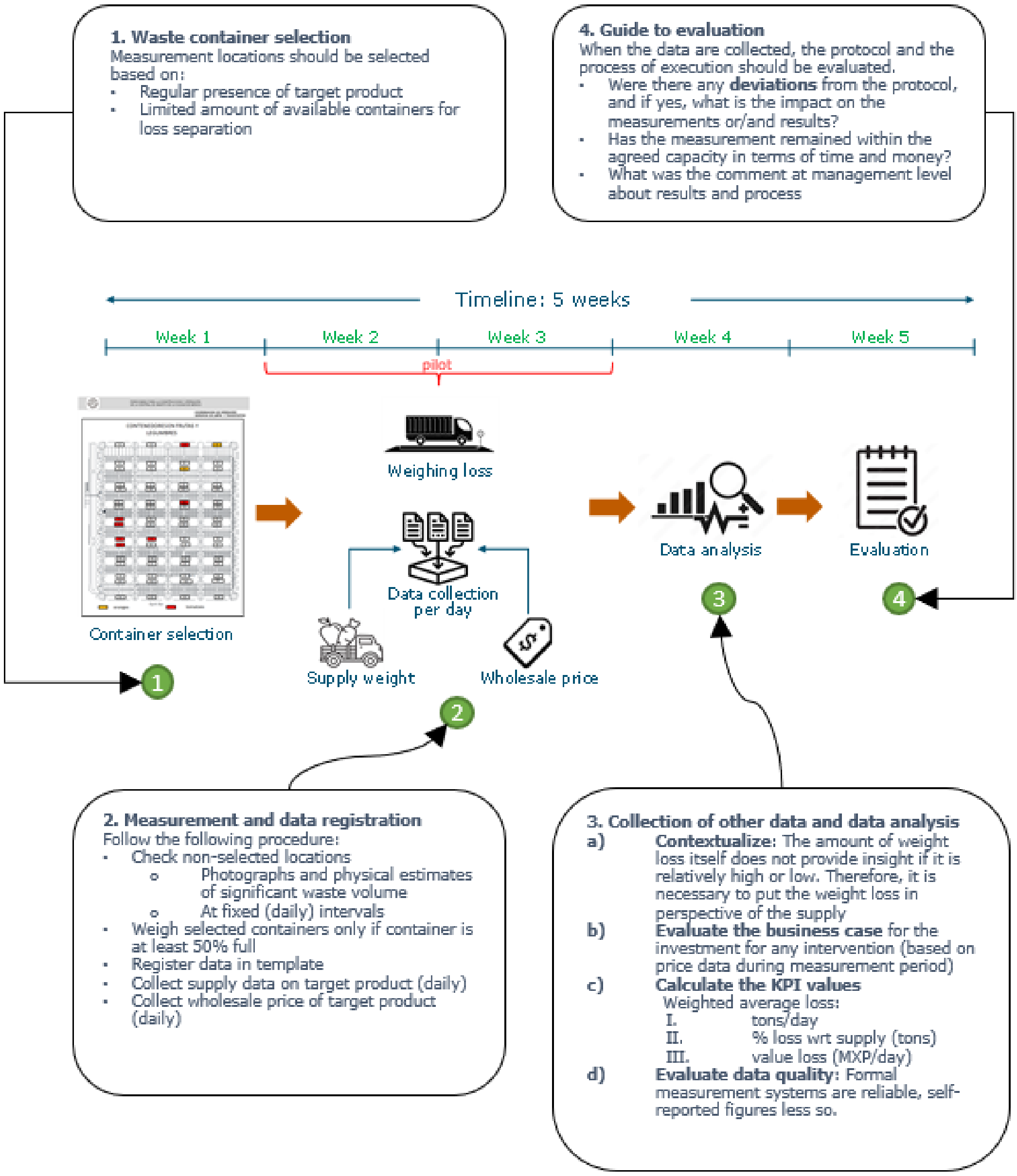
2. Development of Food loss measurement protocol

Before you carry out measurements it is important to determine some starting points.

- **What definition** of food loss and/or food waste is applied?
- **What is the scope?** Which location(s) and what will be measured?
- **Which products** do you focus on? Based on for example price, production, supply, estimated losses, potential valorisation.

Once the products are selected, the monitor consists of **4 steps:**

1. **Waste container selection**
2. **Measurements and data registration**
3. **Collection of other data**
4. **Evaluation**



2.1. Introduction

WUR/FBR together with CEDA developed a methodology to gain reliable data on its food loss. The goal is a protocol to obtain for a certain period an estimate for the absolute weight of food lost in tons as well as the percentage of supply at CEDA for 2 selected fruits and/or vegetables. In addition, as part of the protocol, the value loss is estimated as input for business case calculations with respect to food loss reduction and/or valorisation. The method foresees several steps. The key steps are:

- Analyse current waste management at CEDA
- Scope:
    - Prioritization of 1-2 products within the fruit and vegetable category,
    - Definition of the level of detail of the required data (e.g. variety level red onions, white onions),
    - Determination of the food loss indicator,
    - Inventory of current food loss management.
- Food loss measurements: decide on size for monitoring and the required accuracy, develop a template for the measurements and train local staff on measuring methodology.

2.2. Waste management at CEDA

Waste management is a spearhead at CEDA. In the market there are roads between the sales locations, and many waste containers are placed at the back of plots where the selling takes place. CEDA separates the organic from the non-organic waste in specially designated, and therefore separate, containers for this purpose. The organic waste can go the biodigester or foodbanks, but the capacities are small and hence most of the organic flow is going to composting. All the inorganic waste goes (organic/inorganic mixing) to landfill. If CEDA does not collect enough organic waste and send it to the Transference Unit (in charge of CDMX government), the inorganic waste from CEDA (e.g., packaging material, broken pallets, plastic in general) is not accepted by the Transference Unit. Therefore, CEDA must send some minimal amount (linked to the proportions organic and non-organic waste) of organic waste to Transference Unit, otherwise, CEDA will have to pay certain amount of money per inorganic waste delivered to Transference Unit. After separation, the containers with organic and non-organic waste are weighed on a weighbridge. This logistic infrastructure is an advantageous asset for doing measurements at this largest wholesale market in the world. To describe the daily operations with respect to waste management a detailed hour-to-hour schedule is described below and shown in Figure 3.

Waste management practices:

a) Containers are collected based on route planning at 6am and routes can differ per day; in most cases the routes are similar for about 90%
b) If 50% of the container volume is full, it is collected; if it is almost empty, they do not collect it, and wait for the next day if the 50% is reached
c) The content of the container is weighed
d) Between 6am and 1 am in theory there is at least one person per container, but the daily operation and the capacity of the company in charge of the collecting and separating process, show that in the daily operation there is only one person for attending two containers (for separation organic versus non-organic and the selected crops).
e) Merchants are selling at a fixed spot on the market every day; there only might be one or two seasonal changes throughout the year. Therefore, merchants use the same container every day to discard their waste
f) The distance between two containers is about 185 meters
g) There is a group of about 95 inhabitants of Mexico City that collect edible food loss from the containers for eating or selling. The volume they take is not significant. Furthermore, arbitrary people can take food from the container

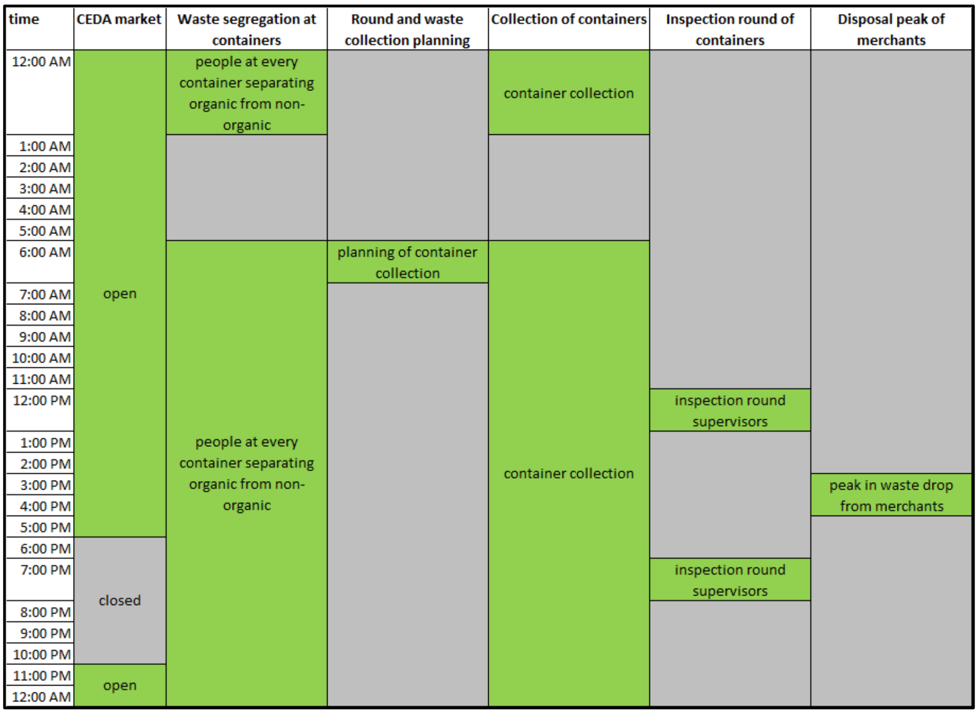


Figure 3 Daily operations in CEDA with respect to waste management.

2.3. Scope

To generate insights for defining priorities, the food loss monitoring should be oriented on what is relevant. Several choices must be made to define the scope of the monitoring, which is an important first step. For instance, CEDA comprises 8 markets; should all be monitored or only one? A second issue is the level of detail of the required data. Is it necessary to orient it on category level (fruits, vegetables), product level (most likely), even variety level (like red onions, white onions, etc.). A list should be provided of what should be measured. A third issue is the indicator that needs to be determined. Options are (per item of the list): weight per day in kg, weight per week in kg per garbage point, % of supplied weight that is wasted on the CEDA, value loss, etc. A fourth issue is the destination. Is it important to know how much is going where, including the food going to the Foodbank ITACATE[2], composting, etc.

The method foresees several steps before providing feasible interventions. Below the key scoping steps are elaborated:

- *Physically*:
    - Geographic: First, the focus is on the fruit and vegetables market (blue rectangle in Figure 1), because it is the biggest market, and it can serve as a pilot (proof of methodology) for upscaling by CEDA themselves later.
    - Product: Selection of 1-2 products within the fruit and vegetable category and definition of the level of detail of the required data (e.g., variety level red onions, white onions), determination of the food loss indicator, inventory of current food loss management.
- *Time*: Food loss measurements: decide on size and duration for monitoring and the required accuracy, develop a template for the measurements and train local staff on measuring methodology;
- *Indicators*: Identification of the 'investment space' (the amount of money which is lost by the relevant stakeholders (mostly traders) at CEDA and could support a business case for food loss reduction interventions and/or valorisation) and the long listing and shortlisting of interventions. To calculate the investment space, weight loss and price level needs to be determined each day of measurement. In this study, if produce is of lower quality and sold with a discount with the intention of human consumption, it is <u>not</u> considered as value loss.
  For the time period of 14 days the following indicators should be quantified:

[2] ITACATE is the food collection and recovery centre at the CEDA market.

- Weight loss in kg
    - % of supply that is wasted
    - Value loss of produce that is not sold for human consumption at CEDA and transported by CEDA in containers to the waste collection point(s)
- *Limitation*: the capacity of extra containers and staff accordingly was restricted to maximum 9. Hence, no more than 9 containers can be selected for measurement. Note that this is a specific condition for CEDA. Limitations (as a general aspect of the methodology) might be different in other wholesale markets.

2.4. Priority product selection

At the start of the project CEDA already selected 5 fruits and vegetables as first priorities for measurements: tomato red, chili, onion, orange, and banana. Although the project is aiming for a measurement protocol for all 5 products, an additional step was taken to prioritize 2 out of these 5 products, that would serve as a test and example for further measurements by CEDA themselves. A simple Multi Criterion Analysis (MCA) was carried out with the following criteria:

- Wholesale price at CEDA (average of 12 months in 2021 in MXN/kg)
- Production weight in 2019 in Mexico (in tons)
- CEDA supply in weight (in tons/day)
- Estimates of losses at CEDA wholesale market[3] (in tons/day)
- Availability (number of high production months/year)
- Number of applications for valorisation

To score the criteria, an equidistant 5 points categorisation was applied, based on the data. An example is given below:

Table 2 Scoring the wholesale price for the 5 products.

Product	Avg price/kg	Categorisation					Score
		Price range					
		5-10 MCP/KG	10-15 MCP/KG	15-20 MCP/KG	20-25 MCP/KG	25-30 MCP/KG	
		1	***2***	***3***	***4***	***5***	
Cebolla Bola 30 Kg. (White onion 30 kg)	MXN 9.58	X					1
Chile Serrano 30 kg (Chili 30 kg)	MXN 28.08					X	5
Jitomate Saladet 30 Kg. / 25 Kg* (Tomato red)	MXN 10.85		X				2
Naranja Valencia mediana Kg. (Orange 1 kg)	MXN 7.66	X					1
Plátano Tabasco 18 Kg. (Tabasco banana 18 kg)	MXN 8.76	X					1

Similarly, the other criteria were scored, and the relevance (weight) of each criterion was set by three departments of CEDA. The result is shown in Table 3:

[3] This seems odd, since the goal of the project is to determine the food loss. However, there is an earlier study where estimates of food loss are derived based on interviews.

Table 3 Multi Criterion Analysis for the 5 products preselected by CEDA.

	wholesale price/kg	production Mex	CEDA supply	Loss	Availability	Valorisation
white onion	1	1	2	5	3	6
chili	5	3	1	1	3	5
tomato red	2	4	4	4	2	6
orange	1	5	3	4	3	6
banana	1	2	5	3	2	6

Departments of CEDA setting the weights per criterion

Innovation	1	2	1	2	1	1
Planning	1	1	1	2	1	2
Operations	1	1	1	1	1	2
Avg. weight	1.00	1.33	1.00	1.67	1.00	1.67

Weighted scores per criteria

Weighted Criteria / Product	wholesale price/kg	production Mex	CEDA supply	Loss	Availability	Valorisation	Weighted sum[4]
white onion	1	1.33	2	8.35	3	10.02	**25.67**
chili	5	3.99	1	1.67	3	8.35	**23.00**
tomato red	2	5.32	4	6.68	2	10.02	**30.00**
orange	1	6.65	3	6.68	3	10.02	**30.33**
banana	1	2.66	5	5.01	2	10.02	**25.67**

Remark: the scoring for 'Valorisation' was carried out by CEDA themselves and does not meet the condition of scoring between 1 and 5 (see Appendix 1). Scoring 'Valorisation' is not straightforward if one do not simply consider biogas or/and compost production. CEDA included the number of applications, and that depends of course on the effort one put in literature research. Since the result after the first 5 criteria could hardly be affected by the valorisation score, and because the top 2 prioritization score is applied for project budget limitations only (the methodology must be developed, independent of the product), there was no need to elaborate further on the MCA. The 2 selected products for this project are: tomato red and orange. There are various tomato varieties, but in this project the focus is on jitomate (red tomato regular), so no green ones or vine tomatoes. Same for oranges; no green oranges, only orange.

2.5. Food loss calculation for preselected product groups at CEDA

In this project a methodology was derived to measure the food loss at the CEDA market. This methodology was tested in the first pilot in May 2022 with tomatoes and oranges. Based on this experience and using the feedback from CEDA the approach was adjusted a little and applied in a second pilot in November 2022 with tomatoes only. In this chapter the process of methodology development is described, and it concludes with the final version of the protocol, which can be applied to measure the weight of other products that end up as loss in the CEDA waste containers.

2.6. Methodology development for measuring

In Section 2.4 red tomatoes and oranges were selected for measurement at CEDA. Since CEDA is a wholesaler, the definition of food loss is required, which is taken from [2] FAO for this project, see section 1.2.

[4] There might be some rounding errors.

Note that inedible parts like peelings are not considered as food loss ([2], p.6-7). Since we selected oranges, this issue plays a role in the absolute weight of food loss. We assume that on average the weight ratio of the orange flesh and peel is constant; consequently, the food loss percentage as part of the supply is not sensitive to measurements of the orange as a whole, including the peel.

Method description

The goal is to determine for tomato red and oranges the weight of food loss in tons as a percentage of supply to CEDA in a certain well-defined period[5]. To this end, a 4-step methodology is proposed. First the steps are described, and a schematic overview is provided at the beginning of this chapter.

<u>How?</u>

Phase 1: Container selection

In the selected area of the CEDA market there are 64 waste container locations (see Appendix 2). Every waste container location has two waste containers, one for organic and one for non-organic[6]. Within the 14 days period before the actual measurement, pictures need to be taken from all 64 containers three times a day at 9, 12 and 16h for one week long. This is necessary to identify the containers that need to be measured. Following the red line in in the picture below (Figure 4) it will take about 3 times 2 person-hours per day to do that, which is 42 hours for the whole week.

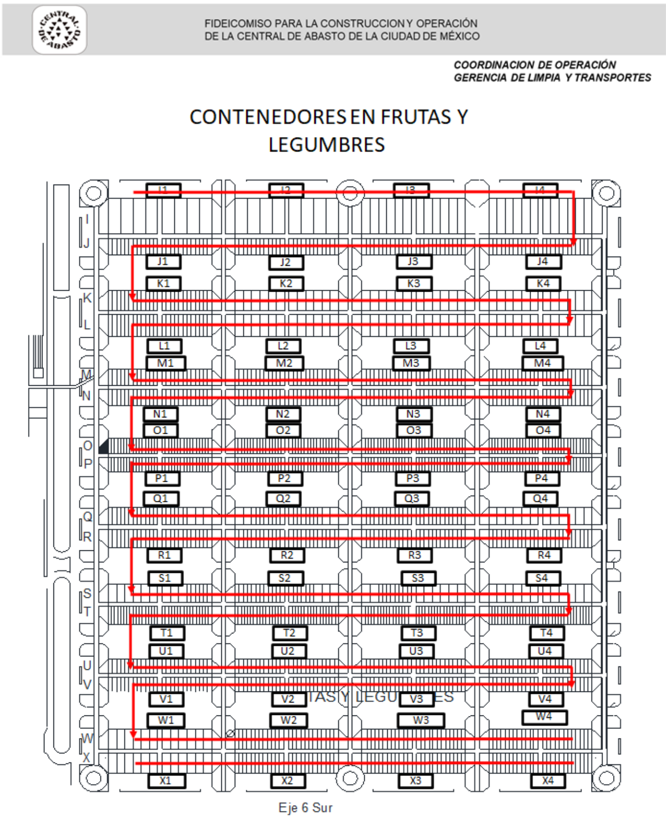


Figure 4 Efficient route (in red) along the 64 containers.

Based on the photographs, the selected products, and the limitations (like not more than 9 containers at the same time) a selection is made for the containers to be measured. If a container showed a significant amount of at least one of the two selected products a picture is taken. Based on determined average weight of tomatoes and oranges (experiment with taking 25 of each randomly and weigh it) a rough estimate of the weight can be derived from the picture. If this estimate is higher than 100 kg, the container needs to be included, otherwise not.

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[5] Later on in this section this issue is discussed in more detail.
[6] A few locations have a concrete U-shape dump place only, where the separation is done using opposite walls.

Phase 2: Measurement of food loss

The protocol for the measurement prescribes, that, at the selected containers, an extra container is available. Normally there are two food loss flows per container location: organic and non-organic, but now the organic is split as well in 'tomato' and 'non-tomato' or 'orange' and 'non-orange.' So, three food loss flows are collected on the selected container locations. Per selected container one extra person was added to the waste separation team. These persons were instructed what tomatoes and oranges should be selected.

Taking pictures of the non-selected containers that have losses from the selected product is relevant for not missing out and checking on deviating behaviour from wholesalers. During the measurement period of two weeks, the same route as above (Figure 4) should be taken along the 64 containers, where the 9 selected ones can be skipped! And this also 3 times a day, like before. We propose a threshold for substantial deviating behaviour: minimum 100kg of the selected product. Thus: **only take a picture when you see more than 100 kg of the selected product in non-selected containers.** The actual weight can be estimated visually, by measuring the size and take the average weight of 25 pieces of the selected product (as we did for tomato and oranges[7]). In practice, 0 to 2 pictures in total are expected per route, so six maximum per day. The estimated weight of these products should be added manually to the table (see Table 4 below), where the data registration takes place of the selected containers. This can be done in 60-75 minutes per route, 3 times a day. One can simply use a cell phone for this (no photographer required) and second if you have two people doing this at the same time, it is done quickly. The only thing is that these people should be able to estimate weight visually, based on the process described earlier.

Table 4 Template for measurement of loss for tomatoes and oranges (example).

Container	Product	Days and dates						
		Mon	Tue	Wed	Thu	Fri	Sat	Sun
		May 16	May 17	May 18	May 19	May 20	May 21	May 22
I3	Tomato red							
K3	Orange							
N3	Tomato red							
P1	Tomato red							
Q1	Tomato red							
R1	Tomato red							
S1	Tomato red							
I4	Orange							
R2	Tomato red							
Weight (kg)	Total							
	Tomato red							
	Orange							

Phase 3: Collection of other data

Supply data: the weight of the food loss itself does not provide insight if it is high or low. In many cases, you can optimize processes to reduce food loss up to 90% or even higher, but the last part requires the most effort, and often is not feasible anymore from an economic point of view. Therefore, it is necessary to put the weight of the food loss in perspective of the supply. Currently, CEDA has no official registration of incoming products. The only way to find out is through traders, who count the supply of the products they trade at CEDA for their own pricing in the morning.

Price data: To avoid or reduce losses, feasible interventions can be suggested. One important dimension of feasibility is value, to find out if the investment for the intervention leads to a sound business case. For that purpose, price data are collected as well during the weight measurement period. At CEDA these data are retrieved daily in an informal way from traders.

[7] The average weight of 25 tomatoes and oranges on the market turned out to be 20 grams for tomato and 250 grams for orange.

Data would be very reliable if there was a formal measurement system, but for now the traders are the best source for input volume and price per day of the selected products. Based on the measured and collected data the indicators described in Section 2.3 can be calculated:

- Weight loss in kg
- % of supply that is lost
- Value loss of produce that is not sold for human consumption at CEDA and transported by CEDA in containers to the waste collection point(s).

Phase 4: Evaluation
When the data are collected, the protocol and the process of execution should be evaluated.

- Were there any deviations from the protocol, and if yes, what is the impact on the measurements or/and results?
- Should the protocol be adjusted or/and be more specific?

When?

- *Measuring period*: measuring is labour intensive and many times costly. Therefore, the measurement period is a compromise between the effort it takes and the reliability of the measurements.
  a. Stable supply and demand: measurements are carried out for two weeks, to study the impact of a particular day and exclude the situation where you have only one single measurement for a particular day. If the supply and demand is stable over the year, two weeks of measurement per year (outside public holidays) is sufficient to have a good indication of the food loss.
  b. Seasonality: But for fruits and vegetables there is the impact of seasonality. The supply of oranges and tomatoes to CEDA is year-round, however there are a few months where the supply has a peak. The impact on food loss for both the absolute and the relative part is unclear. More supply can cause more food loss, but on the other hand prices will drop which stimulates the demand. The starting point is that the measurements in June should be repeated in another season (contrary to current). For tomatoes, the peak season is from November to December, whereas for oranges it is from February to April. Lean season for tomatoes is from April to May and July-September for oranges. Therefore, a second measurement was carried out in November 2022 for tomatoes. Oranges were not measured twice[8], since the first measurement already showed a very low percentage of food loss.
- *Throughput period*: Note that before the measurement some analysis is required (see *How?*), hence the throughput time for one measurement period is about 1 month.

Who?
Since CEDA already separated organic from non-organic in the containers, only a few extra people (in addition to the CEDA staff already separating organic from non-organic at each container) from CEDA were recruited.

2.7. The pilots

In 2022 two measurements were carried out by CEDA. The first one from May 15 to May 31, measuring tomatoes (lean season) and oranges. Since the food loss for oranges was very small, the second measurement involved tomatoes only and took place from November 7 to November 25 (peak season).

2.7.1. First pilot (May 15-31, 2022)

Phase 1: Container selection
Before the measurements, containers were inspected in March, April, and May by taking pictures. Table 5 clarifies the way of working very well. All 64 containers (I1 to X4) from the fruit and vegetables market are

[8] After the project ended a second measurement for oranges was carried out by CEDA in February 2023.

listed. On three dates pictures are taken by CEDA from containers. On March 17 (one time of day) all 64 containers were photographed, which is logical since this was the first time, and no prior knowledge on specific containers with tomatoes was available. Next, pictures were taken on April 22 and May 6 (both three times a day: 9,13 and 16h), but only for a limited set of containers.

Table 5 Overview of container content for tomatoes, before measurement.

Date	I1	I2	I3	I4	J1	J2	J3	J4	K1	K2	K3	K4	L1	L2	L3	L4	pictures per day
March, 17	-	-	T	-	-	-	-	-	-	-	-/FT	-	-	-	-	-	1
April, 22			T	-							FT						3
May, 6			FT	-							-						3
	M1	M2	M3	M4	N1	N2	N3	N4	O1	O2	O3	O4	P1	P2	P3	P4	
March, 17	-	-	-	-	FT	-/-	-/-	-	-	FT	-	-	-/-	-	-	-	1
April, 22						FT	-	-					T				3
May, 6						FT	-	-					T				3
	Q1	Q2	Q3	Q4	R1	R2	R3	R4	S1	S2	S3	S4	T1	T2	T3	T4	
March, 17	T	FT	FT	-	T	T	-	-	-/-	-	-	-	FT	-	-	-	1
April, 22	T	T			T	T			FT	-					-		3
May, 6	T	T			T	T			-	-					-		3
	U1	U2	U3	U4	V1	V2	V3	V4	W1	W2	W3	W4	X1	X2	X3	X4	
March, 17	-	-	-	-/-	-	-	-	-	-	-	-	-	-	-	-	-	1
April, 22				-									-				3
May, 6				-									-				3
WUR		**=no picture taken**			**T=**	**many tomatoes**			**FT=**	**few tomatoes**			**U=**	**unclear**		**- =**	**no tomatoes**
WUR/CEDA																-/-=	**no tomatoes**
		= selected container for measurement															

The classification (as shown below the table) was carried out by WUR/FBR, only if there is a slash in between (-/- or -/FT) two opinions (WUR/FBR and CEDA) about the number of tomatoes on the pictures are given. The following observations can be made:

- The containers I3, P1, Q1, R1 and R2 were clear candidates for measurement
- N3 and S1 are selected but should not be, based on this pre-scanning of the containers
- Q2 is not selected but should be, based on the pre-scanning of the containers

In the evaluation phase, looking at the data, the container selection can be reviewed in hindsight.

Container Q1 16h Container S1 13h Container S2 9h

Figure 5 Examples of container pictures at different time of day (May 6, 2022) (Source: CEDA).

The first week observations showed that there is variation in the number of oranges and tomatoes in the selected containers, and moreover, sometimes other containers have significant amounts of these two products. Looking at Figure 5 Q1 clearly contains tomatoes (selected container) and S2 does not show oranges nor tomatoes (not selected). Container S1 is selected but does not show oranges nor tomatoes neither. This is why one picture is never sufficient for the selection procedure. Therefore, a one-week monitor, prior to the measurement, as described in the protocol (but not carried out accordingly; see Table 5 and Table 6) is advised. Even after a week of monitoring, significant amounts of tomatoes and oranges may be found in non-selected containers. This uncertainty is considered during the measurements, as described in Section 2.6, phase 2.

Like the tomatoes an evaluation table is created for the oranges (see Table 6). The observations for the oranges are:

- I4 is selected correctly
- K3 is selected, but should not be
- N3 and U4 are potential candidates and should have been selected
- Note that the selection of the containers for measurement is not a clear dichotomous process

Table 6 Overview of container content for oranges, previous to measurement.

Date	I1	I2	I3	I4	J1	J2	J3	J4	K1	K2	K3	K4	L1	L2	L3	L4	pictures per day
March, 17	-	-	-	OP	FOP	-	-	-	-	-	-	-	-	-	-	-	1
April, 22			FO	OP/O							-						3
May, 6			-	O							FO						3
	M1	M2	M3	M4	N1	N2	N3	N4	O1	O2	O3	O4	P1	P2	P3	P4	
March, 17	-	O	O	-	-	-	U	FOP	-	-	-	-	-	-	-	-	1
April, 22						-	FO	FO					-				3
May, 6						FOP	UO	FOP/FO					-				3
	Q1	Q2	Q3	Q4	R1	R2	R3	R4	S1	S2	S3	S4	T1	T2	T3	T4	
March, 17	-	-	-	-	-	-	-	FOP	FO	U	-	-	-	-	FO	-	1
April, 22	-	-			-	-			FO	FO					-		3
May, 6	-	-			-	-			-	-					-		3
	U1	U2	U3	U4	V1	V2	V3	V4	W1	W2	W3	W4	X1	X2	X3	X4	
March, 17	UO/UP	-	FO	FOP	-	-	UO	FOP/FO	FOP	-	-	FO	OP	-	-	FO	1
April, 22				UO									FOP				3
May, 6				FO									-				3
WUR		**=no picture taken**			**O=**	**many oranges**			**FO=**	**few oranges**			**U=**	**unclear**		**- =**	**no oranges**
WUR/CEDA																-/-=	**no oranges**
		= selected container for measurement						**FOP=**	**few oranges, many peels**				**OP=**	**many orange peels**			

Remark: it is important to stress that in several cells in Table 6 it says 'OP' or 'FOP'. This means that the losses are peels, and according to FAO these organic flows are no food loss. Although the peels itself are interesting from a circularity point of view, this might lead to overestimating the food loss for oranges.

Phase 2: Measurement of food loss

Technically the measurement was well-organized. The separation of the tomatoes and oranges was okay, and the weighing of the truck as well. However, the registration was difficult to understand. Have a look at the Table 7 below with the first week of measurements (the total data set for the measurements in the two weeks pilot can be found in Appendix 4).

Table 7 Data from CEDA from first week of measurement.

Control de peso de contenedores. De la contaminación hacia una solución circular.

THIS IS THE CORRECT AND FINAL TABLE. ELIASIB PROVIDED THE FIRST INFORMATION ON MAY 17TH 2022.

CONTENEDOR	PRODUCTO	DIAS						
		Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
		16-mei	17-mei	18-mei	19-mei	20-mei	21-mei	22-mei
I3	JITOMATE * 0	0.000	0.000	0.000	1.870	4.310	0.000	2.390
K3	NARANJA *0	0.000	0.000	0.680	0.000	0.000	0.000	0.000
N3	JITOMATE *0	0.000	0.000	0.170	0.490	0.000	0.000	4.670
P1	JITOMATE	4.400	2.330	1.130	1.570	1.490	0.980	3.080
Q1	JITOMATE	5.650	9.070	8.650	5.460	4.550	4.170	5.840
R1	JITOMATE	5.100	4.760	3.080	4.550	6.500	5.640	4.550
S1	JITOMATE	6.900	0.000	0.000	0.000	0.000	4.550	0.000
I4	NARANJA	1.480	2.540	1.690	4.660	5.230	3.620	1.130
R2	JITOMATE * 0*	0	0.750	3.470	2.760	1.000	3.340	1.540
	Total	23.530	19.450	18.870	21.360	23.080	22.300	23.200
	Jitomate	22.050	16.910	16.500	16.700	17.850	18.680	22.070
	Naranja	1.480	2.540	2.370	4.660	5.230	3.620	1.130

*0 SE ANTENDERAN CADA TERCER DIA (the weight will be performed every third day)

0 HASTA EL DIA DE AYER POR LA NOCHE SE HABILITÓ. Included for the WP1 until May 16th 2022.

Without clarification these data cannot be analysed properly. Consider the following observations:

- The value of May 19, container I3, equals 1,870 kg, which represents the total loss of red tomatoes from May 15-19.
- The value of May 18, container K3, equals 680 kg an represents the total loss of oranges from May 15-18. Same for May 18, container N3 (but for tomatoes).
- It seems that the green cell with 0 (May 16, container R2) shows that the measurement did not start that day (neither earlier).
- The value of May 20, container I3 looks extremely high, for a container with less than 500 kg per day in the first days of the week. This could be true but should be checked.
- The value of May 19, container N3, equals 490 kg and is the tomato loss from May 18.

We observe that the way of data collection and registration is chaotic, more based on the daily reality than on rules of the methodology. This in itself is fine, and the team learned to adopt to practical circumstances and changing conditions. Still, although the methodology can be changed, the consistency of registration is crucial, since otherwise, as shown in Table 7, it is impossible to interpret and analyse the data correctly.

Phase 3: Collection of other data

Additional data required are price per kg and weight of supply of the selected products. The approach is described in paragraph 2.6. Both, supply, and price data are not formally identified, but merely collected orally.

In the first pilot, an estimated average of supply weight was provided by the traders (see Table 8).

Table 8 Supply data in pilot phase for selected products.

Product	Average supply during pilot in kg/day
Jitomate/tomato	1,500
Orange	2,000

It is standard procedure that price data are collected by CEDA every day. The data received for this study are from Jan 1, 2021, till May 19, 2022. The pilot was from May 15-31; hence the average is taken from May 15–19. Normally, prices do not change dramatically over a two-week period, so that the calculated average over the available data points is a good estimate for the value loss analysis. This holds for tomatoes as well as oranges. The calculated averages are shown in Table 9 (also, see Appendix 5).

Table 9 Price information on selected products during pilot phase 1.

Product	Average wholesale price based on available data during pilot in MXP/kg
Jitomate/tomato	12.07
Orange	8.08

Gathering all data the requested indicators can be calculated (see Table 10).

Table 10 Results on food loss for tomato and orange at CEDA (pilot 1).

Product	Weighted Avg supply / day (ton)	Weighted Avg. loss / day (kg)	Avg. wholesale price (MXP/kg)	Weighted Avg Value loss / day (MXP)	Weighted Avg. % loss of influx / day
Tomato	1,500	15,291	12.07	184,562	1.0
Orange	2,000	2,734	8.08	22,090	0.1

The value loss for tomatoes is equivalent to € 8,848 or USD 9,013 per day, and for oranges € 1,059 and USD 1,079 respectively[9]. Value loss related to lower prices is not covered here, since it is part of the system. Many (but not all) quality levels find their way towards human consumption. Even the removal of the tomatoes and oranges, which were thrown into the container by the traders during the pilot, is met with resistance in the market, because there are still people who would have liked to extract product for human consumption.

Phase 4: Evaluation

There were no exact agreements on how and when to fill in the data, which is an important lesson to convert to another idea for the new protocol.

- The methodology prescribed a one-week daily observation, prior to the measurements, of all containers with organic waste (3 pictures a day, at 9, 13 and 16h). This did not happen.
- 9 containers were finally selected for measurement (practical upper limit was 9)
- During the week it was noticed that the containers I3, K3 and N3 had not much food loss, and CEDA decided to collect and measure them once every three days. They made the cells yellow when the containers were not measured that day. Other (non-yellow) data points that are zero might as well be non-measured.
    - Of these, in week 2 container I3 was measured four days in a row, instead of once every three days.

  A logical indicator for the food loss would be the lost weight per day, or % loss from supply per day. This was the first suggestion in the beginning of the project. A daily measurement would provide statistic data that can be analysed and lead to an average with a certain (e.g., 95%-) confidence interval. In practice however, this would lead to a lot of additional effort from CEDA, since containers with only tomato loss are not full in one day and measuring them anyway would put pressure on daily operations and the number of containers available for the market. Therefore, the food loss indicator is calculated over the whole period of measurement. In other words, instead of an arithmetic mean a weighted average is derived. Consequently, there is only one measurement (n=1) and it is not possible to generate information on some confidence interval. On the other hand, this measurement provides a better estimate for the annual food loss at CEDA than if it was based on a one day-data point. It is a concession due to the practical circumstances.
- Weighing and product separation was organised well.
- During phase 1 (container selection) a few other containers than the selected ones were photographed (see Table 5 and Table 6), where a significant volume of tomatoes and oranges are identified (see Figure 6). These losses were not quantified from the pictures but should be next time.

[9] https://www.oanda.com/currency-converter/en/?from=MXP&to=USD&amount=22090, viewed 11-7-2022

Q2 May 18 S1 May 20 V1 May 20

Figure 6 Pictures of tomatoes and oranges in containers that were not selected for measurement (pictures taken during measurement period).

2.7.2. Second pilot (November 7-25, 2022)

The second pilot was with tomatoes during peak season. The assumption was that when supply is high, prices go down and loss will increase. Based on the first measurement the protocol was adapted in the sense that daily measurements were not mandatory anymore. The selected container with tomato loss is removed and weighed when it is about 50% full, and at the final day of the measurement period.

Phase 1: Container selection
In the second pilot the selection process of the containers was carried out according to the protocol. A template like Table 5 was used, resulting in the selection of containers P1, Q1, R1, R2. Compared to the seven selected containers in the lean season container I3, N3 and S1 are not selected this time.

Phase 2: Measurement of food loss
Table 11 shows that on many days there were no measurements at all, opposite to what was expected in the peak season.

Table 11 Measurement data from CEDA from in second pilot.

	Measurement start date		7-11-2022							
	Measurement end date		25-11-2022							
	Day nr →	1	2	3	4	5	6	7	8	9
No	Contenedor	8-11-2022	9-11-2022	10-11-2022	11-11-2022	12-11-2022	13-11-2022	14-11-2022	15-11-2022	16-11-2022
1	P1 (kg)	-----	1,170	-----	-----	-----	-----	-----	-----	1,750
2	Q1 (kg)	-----	1,740	-----	-----	4,080	3,170	3,370	-----	2,910
3	R1 (kg)	2,540	-----	-----	-----	7,020	4,070	4,160	-----	4,960
4	R2 (kg)	360	-----	-----	-----	-----	1,270	-----	-----	710
	Total per day	2,900	2,910	-----	-----	11,100	8,510	7,530	-----	10,330
	Day nr →	10	11	12	13	14	15	16	17	18
No	Contenedor	17-11-2022	18-11-2022	19-11-2022	20-11-2022	21-11-2022	22-11-2022	23-11-2022	24-11-2022	25-11-2022
1	P1 (kg)	-----	-----	-----	-----	-----	-----	-----	-----	1,740
2	Q1 (kg)	-----	-----	-----	-----	-----	-----	2,280	-----	1,510
3	R1 (kg)	-----	-----	-----	-----	-----	-----	2,250	-----	1,320
4	R2 (kg)	-----	-----	-----	-----	-----	-----	430	-----	150
	Total per day	-----	-----	-----			-----	4,960	-----	4,720

In total the tomato food loss in these 18 days was 52.96 tons (hence, the **weighted** average 2,942 kg per day). To calculate the food loss as a percentage of supply the supply data are collected per day as well.

Phase 3: Collection of other data
During the second pilot some lessons were learned about data collection. Not only the weight loss data were collected and registered in a better and clear way, also the set up for the collection supply and price data was improved, resulting in better quality of data.

With respect to prices the data again can be found in Appendix 5 (only tomato in pilot 2).

Table 12 Price information on jitomate during pilot phase 2.

Product	Average wholesale price based on available data during pilot in MXP/kg
Jitomate/tomato	22.24

Supply data were available daily for the three types of tomato arrivals: bulk boxes, carton tomato saladet and carton bola (see Appendix 6). No data were available for Sunday November 13 and 20, nor for Monday November 21. Note that November 20 and 21 are holidays in Mexico because of the revolution. Hence, it is assumed that there was no supply on both Sundays and on Monday November 21.

For pilot 2 more detailed data were collected. The average supply of tomatoes was 1,016 tons per day, which is much less than during lean season in pilot 1 (Appendix 6). The weighted average loss for tomatoes was 2,942 kg per day, much less than 15,291 in pilot 1. The average price for tomatoes was 22.24 MXP/kg. An overview of the results for phase 2 is presented in Table 13.

Table 13 Results on food loss for tomato at CEA (pilot 2).

Product	Weighted Avg supply / day (ton)	Weighted Avg. loss / day (kg)	Avg. wholesale price (MXP/kg)	Weighted Avg Value loss / day (MXP)	Weighted Avg. % loss of influx / day
Tomato	1,016	2,942	22.24	65,430	0.3

The value loss in pilot 2 was € 3,137 or USD 3,195 per day. The percentage loss was much lower than in pilot 1 with 0.3% of the supply.

Phase 4: Evaluation
The second pilot was successfully and autonomously carried out by CEDA. The preselection of containers was according to the protocol, and no significant amounts were found in other containers. Based on this experience CEDA will execute a second measurement on oranges in the beginning of 2023 and continue with measuring food loss of other products later.

2.8. Protocol for full-scale food loss measurement at CEDA

Based on the experience from the pilot the following updated protocol version for food loss measurement of fruits and vegetables at CEDA is proposed. The goal is to interfere not too much with daily operations.

Phase 1: Container selection
The protocol prescribed a one-week check of all 64 containers by taking 3 photographs a day (9, 13 and 16h). In the pre-phase of the pilot, as we can see in Table 5 only on 3 arbitrary days pictures were taken. In the evaluation it became clear that other containers than the selected ones were filled with significant volumes of tomatoes and/or oranges (Table 5 as well). Hence the protocol stays as it was in the first place: **fill in the following table and evaluate the pictures as is done in Table 5, Table 6 and Appendix 3**.

Table 14 Container selection template (for tomato).

Date	I1	I2	I3	I4	J1	J2	J3	J4	K1	K2	K3	K4	L1	L2	L3	L4	time of day
Monday																	9h
																	13h
																	16h
Tuesday																	9h
																	13h
																	16h
Wednesday																	9h
																	13h
																	16h
Thursday																	9h
																	13h
																	16h
Friday																	9h
																	13h
																	16h
Saturday																	9h
																	13h
																	16h
Sunday																	9h
																	13h
																	16h
	M1	M2	M3	M4	N1	N2	N3	N4	O1	O2	O3	O4	P1	P2	P3	P4	
Monday																	9h
																	13h
																	16h
Tuesday																	9h
																	13h
																	16h
....																	....
	Q1	Q2	Q3	Q4	R1	R2	R3	R4	S1	S2	S3	S4	T1	T2	T3	T4	
Monday																	9h
																	13h
																	16h
Tuesday																	9h
																	13h
																	16h
....																	....
	U1	U2	U3	U4	V1	V2	V3	V4	W1	W2	W3	W4	X1	X2	X3	X4	
Monday																	9h
																	13h
																	16h
Tuesday																	9h
																	13h
																	16h
....																	....
WUR		=no picture taken			T=	many tomatoes			FT=	few tomatoes			U=	unclear		- =	no tomatoes
WUR/CEDA																-/-=	no tomatoes
		= selected container for measurement															

This can take 2 hours a day for one week, but is necessary to increase reliability and scientific basis. Note that CEDA developed and used a similar type of template themselves (see Appendix 7). This can be used as well.

Phase 2: Measurement of food loss

In the pilot it became clear that the actual weighing was fine, but the data registration was chaotic in terms of clarity (see Chapter 6). Without explanation the numbers could not be interpreted. The protocol aimed for daily registration on the day itself. This was proposed to find out if particular days had more losses than others. However, since the number of containers increased it was difficult to manage their transport and weighing properly, and reality changed plans. For example, some containers were measured every three days or irregularly.

In the new proposal for the protocol the linkage to the day is deleted, and measurement can be done whenever the container has a significant amount of separated produce to be measured. This way operations are easier to organize in combination with the weighing of losses. The template table remains the same, and not all cells need values, only when measured. An example for 2 weeks (May 16- May 29) is shown below:

Table 15 ***Template for data registration of the weighing.***

	Container	Product	Days						
			Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
			May 16	May 17	May 18	May 19	May 20	May 21	May 22
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
	Container	Product	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
			May 23	May 24	May 25	May 26	May 27	May 28	May 29
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									

Data are registered at the day when weighed and always on the last day of the measurement period, independent of the weight on that last day. At the same time all non-selected containers are checked 3 times a day (9h, 13h and 16h) if the product at hand has significant losses. If so, a good picture is taken, and estimates are registered based on volume and average weight.

Phase 3: Collection of other data

Supply data: In addition to the measurements, supply data are required. Currently, no registration of incoming transport is registered formally (it is recommended to CEDA to introduce it). For now, the protocol proposes to talk to at least 3 large wholesalers and ask them what the daily arrival is during the two weeks of measurement.

Price data: The wholesale price is monitored daily (is done by CEDA already).

Phase 4: Analysis of measured food loss results in pilot

By combining the data the indicators for food loss for the selected products can be calculated: average loss weight per day and average % of loss related to the average daily supply (in weight). The value loss per day is at least the wholesale price (MXP/kg) times the weight loss (kg) of the day. Based on interviews additional value losses can be estimated by measurement samples at three wholesalers for the selected product. How much percent of their supply is sold against reduced price and on average what is the price off.

Note that templates can be taken from this chapter and the Appendices.

Phase 5: Evaluation

When CEDA is doing measurements themselves a team should be organized to manage all the tasks. Who is responsible for acquisition of people for loss separation, who is organizing extra containers, data registration, etc. And finally, the team should evaluate the process.

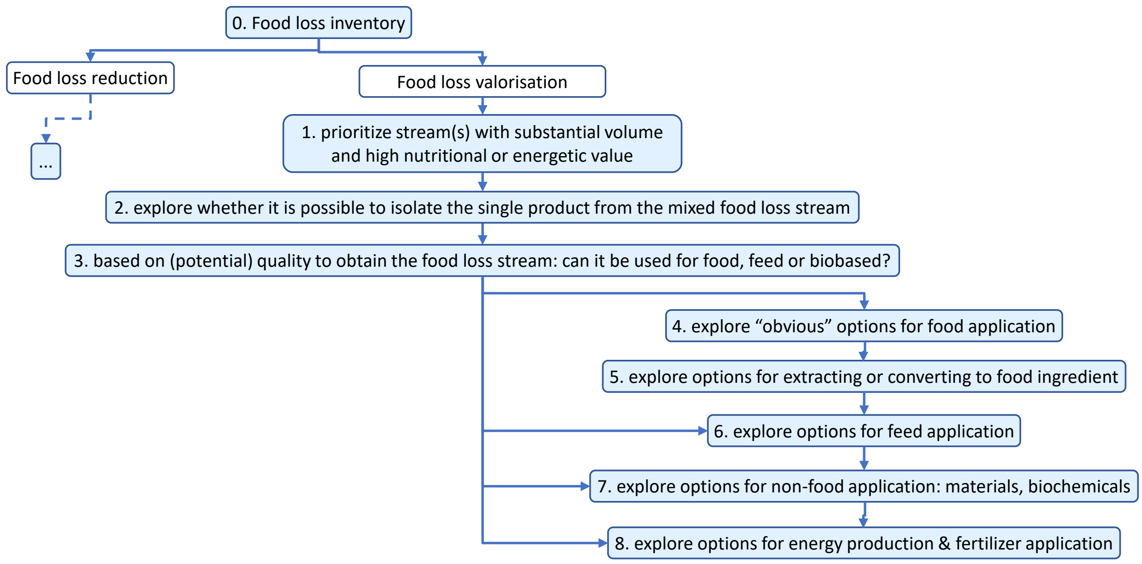
2.9. Conclusion

This project was set up to gain insight in the food loss at CEDA. Based on pilots with tomatoes and oranges a protocol is developed, that on the one hand enables CEDA to obtain the required results on weight and value loss per product and on the other hand matches the practical conditions at CEDA-Operations with respect to waste management.

The conclusions for this the measurement part of the project are:

- The food loss at CEDA for tomatoes is in lean season 15,921 kg/day (weighted average), which is 1,0% of the supply. In peak season it is 2,942 kg/day, which equals 0.3% of the supply
- The value loss at CEDA for tomatoes was 184,562 MXP/day during lean season and 65,430 MXP in the peak season
- For oranges, the food loss in May was 2,734 kg/day (weighted average), which is 0.1% of the supply
- The value loss for oranges at CEDA in May was 22,090 MXP per day.
- The losses are high in absolute weight but very low related to the supply to CEDA market
- The protocol worked out for the CEDA team, and will be applied soon for oranges for the second time, and later for other fruits and vegetables
- During the second pilot, residents of the city regularly visited the waste containers to collect tomatoes. This indicates that they may still be and/or will be used for human consumption. This reduces the losses, which were already relatively small, even more, but this also regularly disrupted the separation process at the containers for the measurements

3. Reducing food waste by valorisation



3.1. Introduction

In the food loss strategy (Figure 2) steps 3 and further are oriented on interventions for the prioritized and quantified loss streams. Since the selected food loss streams have significant volumes, but with relatively low percentage of the total turnover (Chapter 2), food loss valorisation is more promising than loss reduction. For food loss hotspots, valorisation is a valuable strategy, oriented at creation of additional value and/or reducing environmental impact. Valorisation, especially valorisation for valuable products reduces the negative side effects, but goes along with specific requirements. The product should for instance be sorted upstream rather than downstream, selection should take place in a controlled environments, waste products should be separated per product category and/or even per defects, quantities should be ensured year-round, and so on.

The Food Use Hierarchy (see Figure 7) covers a broad range of valorisation options from (relatively low value) composting, to feed application, up to food use (which is appreciated high value).

- *Remark*: Cosmetics and pharmaceutical applications are considered high-value applications. Natural cosmetics and pharmaceutical ingredients are generally extracts from biomaterials. In practice – for economic reasons – often side-streams from food processing are used. For FLW valorisation, this practice may also work, but because the yield of the 'extract' is generally small, the food or feed application should be first identified. Therefore, we recommend to first identify food or feed applications, and next assess whether additional value can be generated by extracting a cosmetics or pharmaceutical ingredient.

In the Food Use Hierarchy, from sustainability as well as from economic and food security perspective, valorisation at the highest possible level is preferred. However, in some situations, the yield at the highest levels may be relatively low, or costs of such solutions are high; then lower value applications may be more preferrable. The challenge is to develop a high value application that is practically doable and delivers sufficient yields.

In exploration studies for high value valorisation studies, commonly either high promises are made on valorisation options, or valorisation takes place on a very low level of the Food Use Hierarchy. In practical opportunity scans, often the business case, relevant legislation, and supply chains and logistics involved are not taken into account. In order to prevent such shortcomings, a tailored tool was developed, which facilitates the identification and prioritization of promising valorisation options. This will guide to valorising the streams that were managed as waste to the highest realistic value in the Food Use Hierarchy. The tool consists of:

- an integrated decision tree model showing under which conditions which valorisation options can be applied (see Section 3.2),
- guides on estimating effects of the intervention on GHG emissions (see examples in section 3.3).

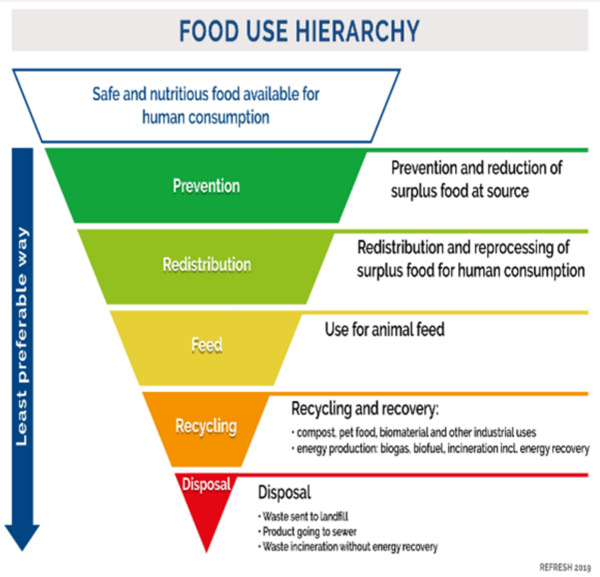


Figure 7 Food Use Hierarchy.

3.2. Decision tree for valorisation options

Food loss valorisation means that the material is derived from the waste streams and used in a valuable application. In such application it replaces traditional "virgin raw materials".

3.2.1. Guiding principles

For valorisation we have formulated a number of guiding principles:

- Requirements on collecting the material: The material ("former food waste") should be treated according to the requirements for the intended application, which means for example that for food application the material should be managed such that it remains food safe. Specific requirements may be related to the composition or properties of the material. Examples: for food application the product should be sorted upstream (when it is still managed as a 'product') rather than downstream (a product that is managed as waste should not be re-introduced as food), selection should take place in a controlled environment, reject products should be separated per product category and/or even per defect, etcetera.

- Local processing: the material is mostly rapidly degradable and of limited economic value, which is a hurdle for costly extra quality management. Local valorisation options or processes that convert the material to a stable product (like a food ingredient) are considered most appropriate.

- Identification of suitable valorisation processes: rejected streams volumes, quality and fluctuations are supply-driven, with a large uncertainty. Consequently, capital-intensive processing, for which return-on-investment is highly dependent on continuity of operation, are considered less appropriate than low-tech valorisation options.

- Market positioning: In case the product cannot compete with "virgin" materials, possibly the reputation of "sustainable" food ingredient or product can strengthen the business case.

- Economic benefits: Savings because less material is sent to waste processing forms an essential part of the business case. Furthermore, the derived food product, food ingredient or other valuable application should either (a) serve as a (cheaper) replacement for a "virgin" source, (b) deliver a final product with higher price than the replacement product delivers, or (c) induce a new service.

- Sustainability impacts: valorising a food loss stream as replacement of a "virgin" source reduces the demand for production (with sustainability impact); furthermore, the volume ending in waste management is reduced.

In identifying options for food loss valorisation, the above guiding principles should be taken into consideration so that ideas that seem attractive but actually will not be successful are avoided.

3.2.2. Decision tree approach

In order to support the process of identifying promising food loss valorisation an 8-stage decision tree approach was developed, built on these principles. This (generic) decision tree (Figure 8) supports the identification of potential FLW valorisation options in any application area, varying from composting, feed to food. The decision tree facilitates the process through the sequence of questions and considerations given per question. The process is kept lean and mean: the greater part of the questions can be based on expert judgement, whereas only a thorough analysis is required for validating the selected ideas (or shortlist of ideas) in the final steps.

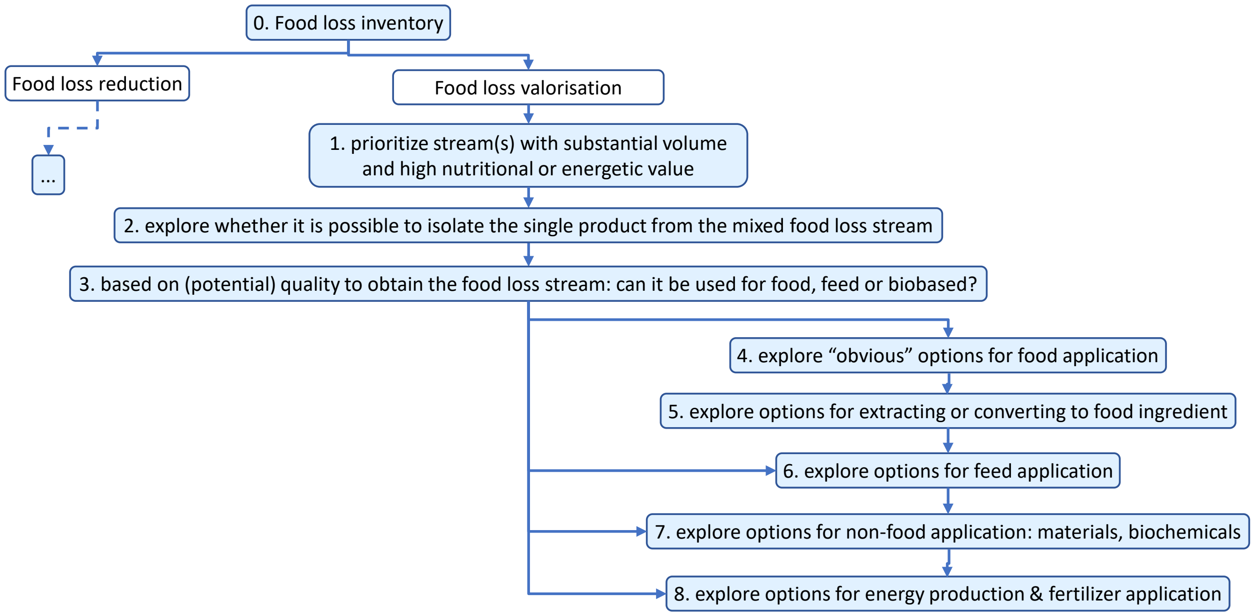


Figure 8 Overview of the decision tree, including some indicative considerations per question.

The decision tree comprises the following phases:

0. <u>Food loss inventory</u>
   This phase is essential for selecting 'hotspot' food loss streams. Phase 1, the Scoping Phase, and Phase 2 the Flow Phase, of the EFFICIENT protocol may be used for this. At this phase, a (rough) notion of food losses volumes is aimed for; often this may rely on estimates from experts. When adequate notion is lacking, data must be collected, e.g. through measurements (see section 2.7).As indicated before, in case of high volume of food loss streams but at low percentage of the actual throughput, developing loss valorisation options is the most obvious strategy.

> Although the volume of food losses generated at CEDA market is enormous the percentage of the losses at CEDA is limited. Therefore, in the fight against food losses, valorisation is considered more promising than food loss reduction.

1. Prioritize products with high volume and substantial nutritional value and/or energy
   In line with Phase 3 of the EFFICIENT protocol (Focus), priority food loss streams are chosen (specified product or set of products, lost in a specified stage of the value chain or at a specific chain actor). This selection is preferably made by an actor or a group of actors who can benefit from the valorisation (e.g. by reducing the economic losses or the costs of waste management). Next to the volume of the food loss stream, also the potential value of the wasted product can be included in the selection criteria. Potential value is estimated in e.g. nutritional value (relevant if the food loss stream can be upgraded to a food or feed application) and energetic value (relevant for bioenergy or biobased application). For this (and next) phases typical compositional and nutritional information can be found in the following integrative datasets:
   - foodwasteexplorer.eu, which presents contents of a large group of components as well as nutritional and energetic value of a large set of food waste streams.
   - https://eu-refresh.org/waste-pyramid.html presents 76 practical examples.
   - www.feedipedia.org, which lists all major sources for feed ingredients: dedicated feed crops as well as food processing by-products and (processed) food products (describes a.o. nutritional value for feed application).

   Based on an inventory done by CEDA and supported by WUR tomato and oranges were selected because of the relatively large volumes of these food loss streams at CEDA market.

2. Explore whether it is possible to isolate a single product from mixed stream
   A single-product stream can be used in more dedicated applications than a mixture. Consequently, it is recommended to first explore valorisation options for the single product (phases 4 to 7 below). If the product cannot be separately collected or separated from the mixed waste stream, or if no promising valorisation ideas can be identified for the single-product stream, phases 4 to 7 can be checked for the mixed stream.

   The streams of rejected tomatoes and oranges are generated by traders who trade these as dedicated products. Consequently, separate collection is possible, and can be applied in case of an attractive business case.

   Next phases (exploration of options for diverse application) can be done based on:
   - Experts brainstorming
   - Internet search for practical examples

   Note: In scientific publications many novel ideas for food applications, processing, extraction, etcetera are presented and explored. Often, these are not (yet) suitable for practical application. In general such novel ideas are most suitable for materials with well managed quality. Therefore, it is not recommended to explore scientific literature for this purpose. Professional literature is considered more relevant because they present amongst others practical examples.

3. Assess whether it is realistic to expect whether the stream could be used for food, feed, or biobased application, based on the following considerations
   a. Safety: can the stream be collected in food or feed grade status?
   b. Could the ‘waste’ be collected with controlled safety?
      Fungi (producing toxins) should be prevented.
      Bacterial hazards may be reduced by thermal treatments
   c. Would the product serve as an interesting food/feed ingredient product?

   This exploration can be done with a small group of experts, preferably based on a site visit (which is aimed at getting a good notion of the status of the food loss streams).
   In case food application is considered realistic the process is continued at phase 4; if feed application is the ‘highest realistic option the next phase is 6; if biobased application is considered most realistic the next phase is 7. If none of these options is considered realistic, phases 4 to 7 are skipped.

From an experts site visit to the CEDA market it was concluded that:

- It is not realistic to isolate tomatoes from the waste stream at food or feed-grade status; for this product stream phase 8 is most applicable.
- Oranges may be acquired in food or feed-grade quality; for these the process may be continued at phase 4.

4. Explore options for food application

Only applicable if the product (at the moment of reject) is still food-grade. This in general means that the product is not heavily damaged and not microbially infected.

Think of common uses of the food product. Some guiding questions:

- Can the product still be marketed as a whole food product (possibly at depreciated prices or as a donation)?
- In case the product is still edible: is a local market available?
- Is the quality (think of state of ripeness, percentage of damaged material, etc.) adequate?
- In the case of surpluses in peak supply seasons: can the products be processed to shelf-stable products that can be traded elsewhere or in low-supply reasons?
- In the case of rejected products that are considered not fit for surviving the complete supply chain: can they be processed to a processed food product or ingredient?

Ideas should be critically evaluated (as described above). Especially be aware of competition in the intended market: can the product based on the rescued food loss compete on product characteristics (or sustainability image) with 'regular' products? In order to sustain a good relationship with the companies who provide the food loss stream, competition with the regular traders of the product should be prevented. Also, continuity of volumes of the food loss stream may be critical: in case of capital-intensive processing line the continuity of operation is critical for the business case.

Rescued oranges may be donated to food banks

5. Explore options for food ingredient extraction

If the whole product cannot be converted to a food product (phase 4), it is still worthwhile to explore whether a fraction can be used for food application (if the lost material can be collected at food-grade quality status).

Critical remark: this may be capital-intensive.

Rescued oranges may be directly applied for production of fresh or pasteurized orange juice.

6. Explore options for feed application

Inspiration on relevancy for animal feed can be obtained by searching for the food loss stream on feedipedia.org. In case of substantial nutritional value, also the idea of producing feed production through novel pathways (like insects) may be explored. In scientific literature yields over 100kg insects (black soldier fly) per ton food waste are presented. The residue of insect production (frass) is a high-value fertilizer. Insects are interesting for chicken feed, but at limited ratio in their diet. Regulatory issue: are insects grown on waste streams allowed for feed?

Current state-of-the art:

- Commercial scale for high-value markets (like fish feed for aquaculture)
- Diverse local examples for chicken feed; most at demo scale

Orange peels are interesting feed for cattle; these can be provided:

- Fresh (with limited time from generation to feed application; maximum 3 week if they are kept in moderate to cool condition). Because of the high moisture content distribution over large distance is very unfavourable in the business case.
- Dried (only feasible at large volumes because of the capital-intensive drying equipment).

7. <u>Explore options for non-food application: materials & biochemicals</u>
   Inspiration may be found on e.g. foodwasteexplorer.eu
   Relevant criteria:
   - Does the material contain interesting (macro-)structure (fibres)?
   - Available carbohydrates may be relevant for bio-chemical building blocks
   - Would a local market be available?
   - Is it expected that these food loss-derived materials are more sustainable than the products already on the market?

   The business case will depend on seasonality of substantial loss volumes and simple (inexpensive) or existing processing facilities

   Limonene can be extracted from the orange peels without affecting the feed nutritional value.

8. <u>Explore options for energy and fertilizer application through bio-digestion</u>
   Final option, be aware that biogas production can co-exist with organic fertilizer production. The actual bioenergy yield will depend on dry matter content, composition (especially macro-nutrients fat, carbohydrates, and proteins) and hindering ingredients (like inorganic materials, bones, etc.). Other criteria for this valorisation are the local market for energy and regional demand for fertilizer (digestate, compost). Be aware that a biogas plant requires mixed feedstock.

   Recommendations for CEDA:

   - Yield to biogas from tomato is relatively low because of low nutritional energy content and low dry matter content;
   - Orange peels are allowed, but at limited dosage: this is maximized by the limonene content.

3.3. Valorisation case studies and factsheets

In this chapter four valorisation pathways are described in depth.
Currently about 90% of the organic waste of the CEDA goes to a composting plant and 10% goes to the biogas reactor. Below higher valorisations are explored (see Figure 7).

3.3.1. Case 1: From Waste to Value – Oranges

Feedstock
Unsold Oranges
A percentage of the Oranges offered at the market will not be sold and are being discharged. However, these oranges can still be utilized for different purposes, as long as it does not affect the regular business, depending on their quality and reason for being removed.

New Market Destinations
Food banks, juice producers, ruminants
The valorisation options for oranges depend on their quality. Even from rejected oranges is it still possible to use a part of the oranges after sorting adequate quality.

- In case of oversupply, donating them to a food bank can be a desirable choice even though it will not generate any revenue, as there will not be any disposal costs either.
- Another option is to sell discounted oranges to a preferred juice processor, provided they agree to buy all the oranges consistently. Next to that, traders can also set-up their own juice factory/supply at the market. As the production will be pushed by the supply the juice will have to be pasteurized to make the juice shelf-stable and avoid waste.
- Additionally, non-rotten oranges can serve as feed material for ruminants, which value the fruit for its nutritional value and health benefits due to essential oils present in the peel (see also fact sheet orange peel valorisation). To enable efficient transport, high volumes are needed (full truckloads). Whole oranges can also be combined with orange peels to increase the total volume.

Process Description
The unsold oranges need to be graded to quality requirements of final destination. High-quality lots require defect removal, while lower quality lots need selection of sound oranges. This sorting can best be done with sorting table, where the oranges are rotated during transport over the table for complete inspection. The defects or the sound oranges can then be manually removed from the table. After the sorting, another round of grading is needed to determine the suitable applications for the oranges.

Visuals

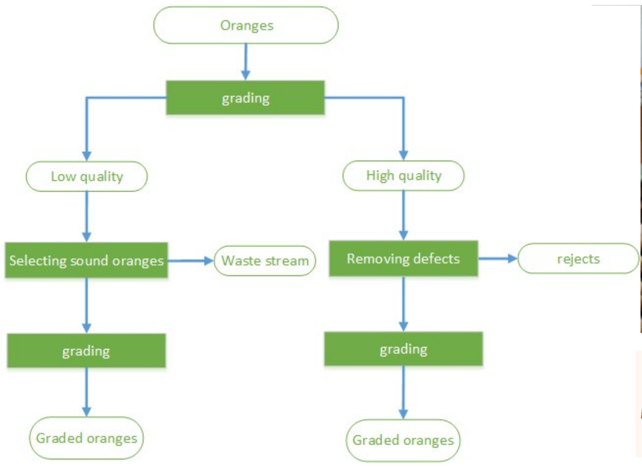


Photo by: BIJLSMA HERCULES

Figure 9 Left: the sorting process for Oranges - Right: A rotating sorting table.

Business Case

Agreements need to be made with food banks, juice producers and cattle farmers for the delivery of the oranges. These agreements need to have four elements: quality standards (amount of rot, damaged, immature Etc.), price, min-max volume, and limitation on use. The latter is important to avoid that the buyer going to use the oranges as trade conflicting with the market of the seller. With these agreements, for every offered lot of oranges it can be decided if sorting out will be paying off. The sorting capacity and associated costs depend on the number of defects in the raw material since one person can sort between 60-120 oranges per minute. Some of the defects will not be detected, ending-up in the cleaned stream lowering the quality of this stream. It is likely that the number of undetected defects is correlated with the number of defects in a stream. If the number of missed defects becomes too high or more than 50% of the oranges have defects, the sorting process must shift from removing defects to selecting sound oranges. The total sorting costs mainly depend on the quality of the oranges when removing defects, as this determines the necessary workforce. However, if the quality is so poor that it requires selecting sound oranges from the entire stream, the costs will be higher but less dependent on the raw material quality.

Discussion

The feasibility of the above solution to decrease waste and economic losses will heavily rely on the effort required to arrange agreements with buyers and the quality of the available lots. The sorting process itself is simple and highly scalable, making it a low-risk investment.

Suggested Next Steps

Create a grading system for the unsold oranges and try to match that with possible buyers.

Environmental sustainability analysis

The carbon footprint of oranges traded at CEDA market is estimated (through the ACE calculator) at 0.31 kg CO2-eq. per kg sold at CEDA market, with main impact factors:

- Agricultural production: typically 0.2 kg CO2-eq. per kg (average estimate of values presented by from Porter et al. (2016), Bell et al. (2020) and Bonales-Revuelta et al. (2022)).
- Assumed transport distance 300km, large truck.
- Losses/rejects in the postharvest/collection phase: typically 14% (Porter et al., 2016).
- Around 2% loss at CEDA market (landfilled)

Carbon footprint of orange juice from purchased vs. "rescued food loss" oranges (assuming 50% juice yield from extraction):

- 0.62 CO2-eq. per kg for juice from purchased oranges,
- -0.40 CO2-eq. per kg for juice from rescued oranges (negative because landfilling is prevented).

Apparently, valorising the rescued oranges for the food product contributes to reducing environmental sustainability impact.

3.3.2. Case 2: From Waste to Value - Orange Peel

Feedstock

Orange Peels direct from juice manufacturers

Challenges and limitations associated with using this type of feedstock: To prevent spoilage of oranges, they are commonly treated with fungicides such as imazalil, thiabendazole, pyrimethanil, azoxystrobin, and fludioxonil. These fungicides are applied to the peel, so there is usually no risk to the safety of the juice or flesh. However, when processing the peel to feed or food, the fungicides can be concentrated in the extracted products, making them unsuitable for certain food applications. Therefore, products derived from the peel may not always be appropriate for use in food.

New End Products

Interesting valuable end products that can be derived from the waste/side stream are:

- essential oil (such as limonene)
- pectin, and
- feed

Essential Oil
The flavedo, which refers to the outer yellow peel or epicarp, contains concentrated essential oils, particularly limonene, which can be extracted using special pressing and water-oil centrifugation (Teigiserova et al. 2022). Although the yield is relatively low (up to 0.2% of wet peels), the extracted oil has a strong orange flavour and can be used in cleaning agents, as well as a flavour in food. The oil has a strong antibacterial activity.

Pectin
The albedo, which refers to the inner white spongy peel or mesocarp, is rich in pectin, a gelling agent used in food processing. About 20% of dried peels can be extracted as pectin, corresponding to 4-5% of fresh weight (Hosseini et al. 2016). Pectin extraction is a complex process usually performed in large factories, making it more suitable as a raw material for existing pectin factories rather than building new ones.

Feed
Finally, the whole peels can be utilized as feed material for ruminants, such as cattle (Bampidis et al. 2005). Fresh orange peels are appreciated by ruminants and have good feed value, as well as potential health benefits due to the essential oils present in the peel. To minimize transportation costs, the distance to cattle farms should be short or the peels need to be dried prior to transport.

Table 3
Chemical composition

Citrus by-product	Dried orange pulp (NRC, 1988)
DM[a] (g/kg)	880
OM (g/kg DM)	962
CP (g/kg DM)	85
Crude fat (g/kg DM)	17
NDF (g/kg DM)	210
ADF (g/kg DM)	160
Lignin(sa) (g/kg DM)	–
NE_l (MJ/kg DM)	7.49
NE_g (MJ/kg DM)	5.19
NE_m (MJ/kg DM)	7.86
Calcium (g/kg DM)	7.1

Pre-Treatments
Oil extraction from the waste/side stream does not require any pre-treatment. However, to extract pectin or utilize the peels as feed material, some processing is necessary. This typically involves screw pressing, cutting, or drying and coarse grinding of the fresh peels. Pressing or cutting the peels can increase the dry weight slightly, but more importantly, it significantly increases the bulk density, which lower the cost of transport. Drying the peels, if a cost-effective option such as sun drying is available, can further reduce transport costs and extend shelf life.

Process Description
To obtain high-quality essential oil, the orange peel must be collected regularly from juice producers, as fresher peels have higher oil yields. After sorting out any contaminated peels and foreign objects, the peels are pressed to extract the oil, which is limited in quantity. Water is needed to collect the oil droplets, and the resulting oil/water mixture is sent to a centrifuge to separate the essential oil and water for reuse. The extracted oil contains mainly D-Limonene, along with some other oils and wax from the peel surface. To purify the D-limonene, distillation is typically required; this may be done at another site than the peels processing location.

The peels can be cut or pressed to increase the bulk density, which reduces transport costs. The peels have a relatively long shelf life (up to 3 weeks) due to their antimicrobial properties when kept at moderate or low temperature. As there will be still D-limonene in the peels after the oil extraction it is not expected that the oil pressing influence the shelf life of the peels. Therefore, even after the oil extraction, the peels can still be sold directly to cattle farmers or pectin factories, or dried to stabilize them for long-term storage and further reduce transport costs. The moment of oil and pectin extraction is not critical, so the peels can be prepared for transport directly after screening, postponing oil pressing. This provides additional flexibility in managing the waste/side stream and allows for customized processing based on market demand.

Visuals

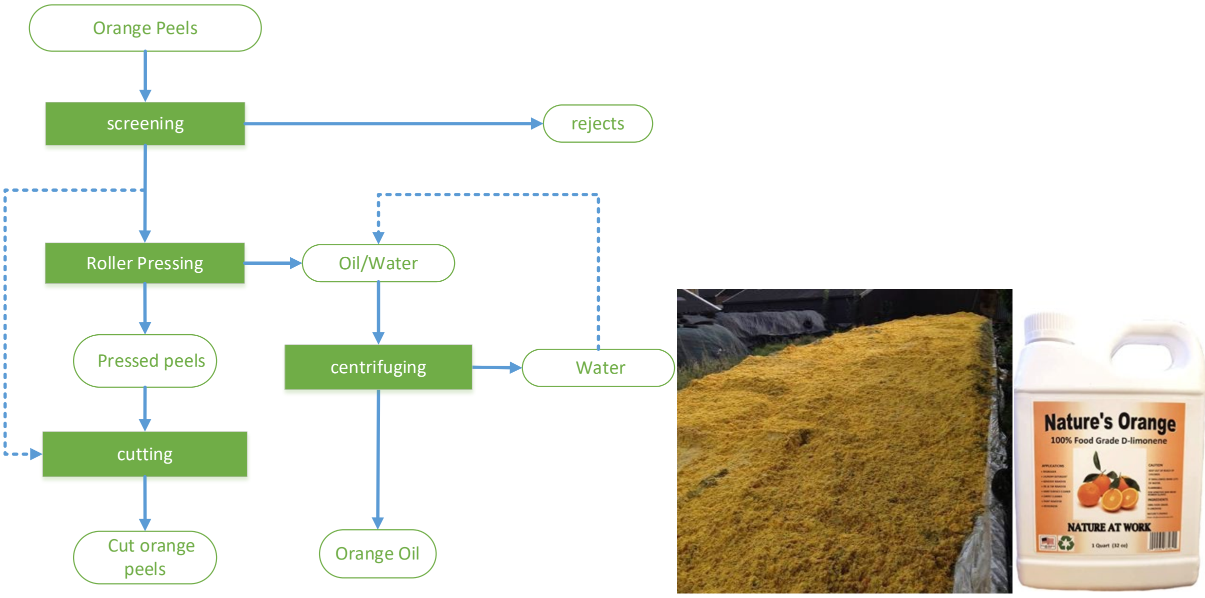


Figure 10 From left to right: The process and its end-products, cut orange peels and orange oil.

Sustainability analysis

The intervention contributes to reducing environmental sustainability impact of waste management (typically 0.8 kg CO2-eq. per kg food waste). Furthermore, in the application, the peels reduce demand for other feed components. 1kg peels as-is (wet) replaces 0.2kg dried citrus peels, with typical carbon footprint 0.5 to 0.7 kg CO2-eq. per kg supplied (GFLI, 2022). Thus, replacing the feed product contributes to saving 0.12 kg CO2-eq. per kg fresh peels supplied as feed.

Business Case

The feasibility of using peels for feed or pectin largely depends on transport distance (most relevant for supplying fresh peels) and volume (critical for drying), as revenues are typically only in the range of a few USD cents/kg. However, if juice producers must pay for peel disposal, it can help create a positive business case. Therefore, by collecting and marketing the peels as a valuable by-product, companies can generate additional revenue and reduce their environmental impact.

Discussion of the risks and challenges

All major fresh juice producers in the Netherlands currently sell their peels as feed for ruminants, indicating that the presence of fungicides is not a concern for this application. While there have been attempts to sell the peels to a pectin factory, the transport distance was too far to make it feasible.

In the Netherlands, only one company produces orange oil from collected peels. It is unclear whether this is due to a strategic/financial decision or a consequence of the other suppliers' juice pressing process, which may render the peels unsuitable for cold oil pressing. Regardless, making the oil production profitable will be challenging due to the low yields and potentially high marketing costs for the limited available volume.

Overall conclusions

Utilizing orange peels for feed or pectin production is a low-risk short-term option, while oil extraction from the peels is challenging due to its low yield and the need to sell the remaining spent peels. Adding oil extraction to the process can be considered once the peels are successfully marketed. The feasibility of marketing the peels for feed will depend on the collection volume and transport distance. Fungicides applied to the oranges after harvest may not be a concern for feed application but may pose an issue for any food sector application.

Examples/Links
Below we give a list of examples and links to businesses and organizations that are already valorising these waste streams from oranges:

- Peelpoineers: https://peelpioneers.nl/home-en/. Peelpioneers collects peels from retail to produce oil, fibres, and animal feed from it.
- Van Vulpen Veevoerders: www.vanvulpenveevoeders
  Van Vulpen Veevoerders sell orange peels, probably as a broker for the fresh juice industry, as cattle feed

Suggested Next Steps

- Check whether there are large cattle farms in the neighbourhood and examine their interest in orange
  peels as additional feed material.
- Check whether there are existing pectin factories in the vicinity

3.3.3. Case 3: From Waste to Value: Insects from mixed market waste

Feedstock
Mixed fresh market waste: residues of vegetables, fruit, meat, poultry, fish; preferably segregated organic fraction only (limited amounts of plastic, paper, metal, glass, and stones are still allowed) e.g. peelings, inedible parts, kernels, unsold fruit, and vegetables. If no meat, poultry, and fish are included, plant protein sources like beans will be important for the insects. Segregated collection at the market is important since the insect culture cannot handle too many pieces of plastic, paper, metal, glass, and stones. Furthermore, such impurities are troublesome in the handling. It depends on the Mexican law if a clean collection (feed grade) is required.

New End Products

- It is proposed to produce black soldier fly larvae as these can be grown on relatively wet substrates. Ideal is that the market waste does not need to be very clean and that the larvae are acceptable as feed e.g. for chickens (dependent on national legislation). The future alternative is to use the larvae for human consumption, but then the waste collection should be feed grade. Another alternative is to use the larvae for non-feed-food applications. The residue (frass) after larvae cultivation can be used as a fertilizer (it looks like compost).
- The benefit of this route is to utilize the market waste as feed, which avoids acres of feed crops (land sparing and resources required for cultivation). The action increases the circularity and sustainability of the food system. Insect meal can partly replace other protein sources in e.g. chicken and aquaculture feed. Various application opportunities have been identified for insect oil, varying from biodiesel, cosmetics to food application. The chicken feed market in Mexico is very large: enough chickens to feed on insects grown on all market waste.

Pre-Treatments
A size reduction is required to 1 cm to enable separation of the larger larvae from the substrate (residue) and to increase the edibility for the insects. The market waste should be combined with a protein source if it is expected that the protein content is low. The addition of wheat bran to improve the structure and to absorb water may also be required.

Process Description
After size reduction and mixing it with a protein source and wheat bran, the substrate is spread over the bottom of a crate (tray), usually of 60x40x19 cm, and incubated indoor in stacks of crates, under controlled conditions with respect to temperature (27°C), humidity (60-70%) and air quality. Ventilation is required. The substrate should contain 70-80% moisture. The insect eggs are kept in pop-up nets for 5 days to develop into larvae, which are then transferred into the crates, where they are regularly fed with the feedstock, usually three times per week. Larvae can grow up to 25-30 mm in length and 6 mm in width, and may reach a weight of over 200 mg. The larvae are voracious eaters and can consume several hundreds of grams of organic matter per larvae per day. They feed on almost all decaying organic matter and can mature in about six to eight weeks under ideal circumstances. After having grown to maturity, the larvae will stop

eating and start to pupate. They can then be harvested using a sieving systems, either small-scale by hand or automated for larger scale operation. The frass is passing the sieve and the larvae stay are retrieved on the sieve. Larvae can be killed using various methods e.g. thermal.

Visuals

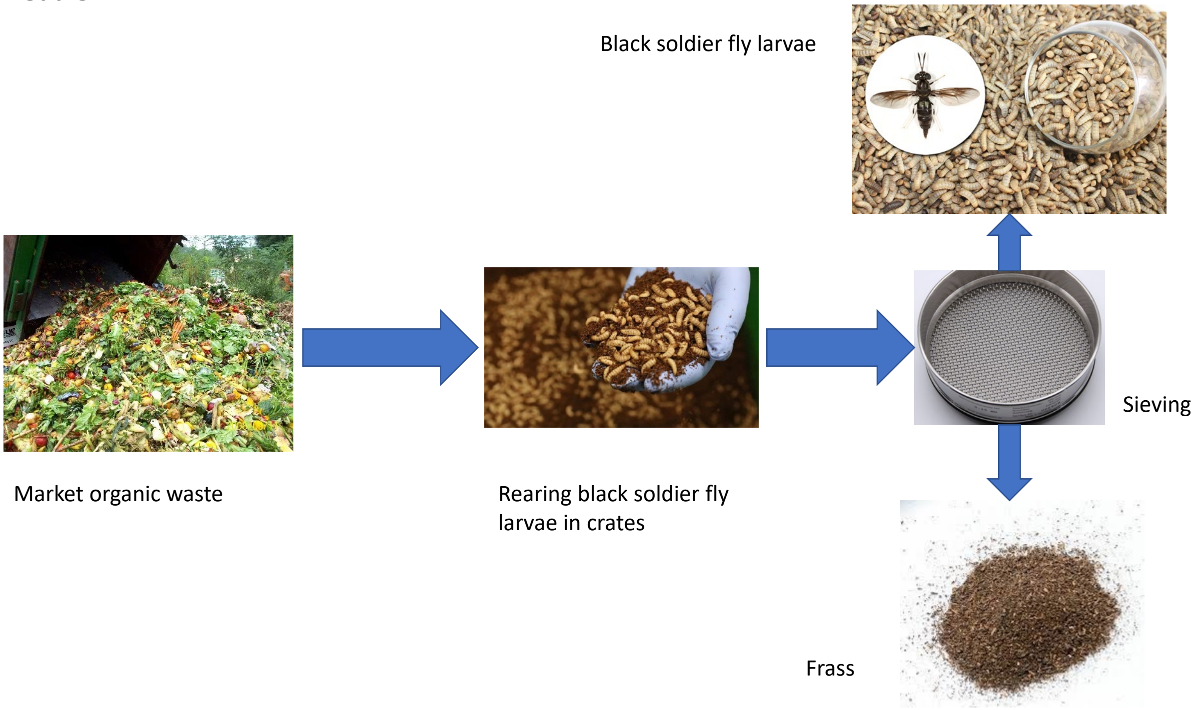


Figure 11 Process flow black soldier fly larvae.

Business Case
According to [5] 125 kg of black soldier fly larvae and 250 kg frass can be produced from one tonne of vegetable/fruit waste. Cies Oskam (NGN) has proposed a value of 1.20 Euro per kg BSF larvae and 40 Euro per tonne frass. That means that 160 Euro products can be gained from insect cultivation per tonne of vegetable/fruit waste. Most of the costs will be in the production process, it depends very much on these costs if there is room to give the market waste a value.

Regulatory issues are: how clean the market waste should be collected for various insect applications? The chain should be developed: One missing link means failure. The waste segregation should be organized, permits and capital are required for constructing an insect farm and the insects and frass should be sold.

Examples/Links

- Protix is a large insect production company in the Netherlands (https://protix.eu/#). It produces black soldier fly larvae on food residues (not totally the same as market residues) which can be used as such in chicken feed or can be separated into fractions, e.g. the protein fraction and the lipid fraction, that are both used for pet food. Equipment was supplied by Bühler.
- Most examples of insects production on food waste streams are done on laboratory scale, but there is increasing attention for industrial-scale production. For instance in [6] a full scale plant in China is described, in which organic waste from restaurants is used to grow BSFL.
- Wageningen University is testing black soldier fly larvae cultivation of kitchen waste and many other sources. Many other research groups are active in black soldier fly cultivation. Several substrates for BSFL are reported in literature. Growth was observed in the type of substrates given below, sometimes as part of a mixture and sometimes as a sole substrate.
    - Manure: Horse manure, cow manure, sheep/goat manure, chicken manure, duck manure and the solid phase of pig manure.
    - Legally allowed, clean, high value substrates: Wheat bran, brewery spent grain, pineapple grain, maize bran, soybean bran, palm seed meal and poultry feed.
    - Meat meal derived from slaughterhouse waste.

- Household and restaurant waste and related substrates: kitchen waste, canteen waste, restaurant waste, domestic or municipal organic wastes, agro-industry by-products, food processing waste, deteriorated fruits and vegetables, coffee grounds, chicken meat, eggs, and banana peels.

The growth observed was acceptable.

Suggested Next Steps

- Involve insect experts, ask the opinion of the Mexican owners of the market waste, search for insect farms in Mexico.

3.4.4. Case 4: From Waste to Value; Biogas from mixed fresh market waste

Feedstock

- Mixed fresh market waste: residues of vegetables, fruit, meat, poultry, fish: segregated organic fraction only (limited amounts of plastic, paper, metal, glass, and stones may be allowed, depending on the specific technology options) e.g. peelings, inedible parts, kernels, unsold fruit, and vegetables.
- Segregated collection at the market is important since the biogas plant cannot handle too many pieces of plastic, paper, metal, glass, and stones. Too much citrus fruits may inhibit the biological process (because of limonene) in the biogas plant.

New End Products

- The fresh market waste will be converted into biogas and a digestate. The biogas can be used to produce heat (for local use), electricity (in an electricity generator), it can be purified and introduced into a local natural gas grid or it can be purified and compressed to produce bottles or tanks with CNG (compressed natural gas) or Bio-LNG (liquified natural gas). Compressed carbon dioxide (obtained in the gas purification process) in bottles may be an optional co-product. The digestate can be separated into two fractions: a solid fraction which can be converted into compost and a liquid fraction which can be processed in a larger composting plant, discharged into a sewer, or treated and used as nutrient-rich irrigation water/fertilizer in agricultural crop land.
- The biogas is the main product: it is a renewable energy and can be used to replace fossil energy (natural gas, oil, coal). If it is converted into electricity it is renewable energy as well. It depends on the local situation if it is interesting to introduce the gas into a gas grid or put the gas in bottles to be sold elsewhere, or produce electricity and introduce it into an electricity grid. It depends on the availability of gas grids and electricity grids of sufficient capacity near the place of the biogas plant. In addition, it depends on local feed-in tariffs: does the biogas plant owner get a price for gas or electricity introduced into the grid? The market can easily absorb the amounts of renewable energy produced; it is large enough and government policies stimulate the production of renewable energy.

Pre-Treatments

- Segregation of the waste; remove as much as possible pieces of metal, glass, paper, plastics, and stones. Also large pieces of wood should be avoided. Such segregation may take place by using different bins at the market or later by hand picking (using conveyor belt). The dry matter content of the ingoing organic fraction from the market is 14%. That means that it contains 86% water.
- Shredder to cut the waste in small pieces.
- Macerator pump that further reduce the size of pieces; mixing with recycled effluent; the slurry can be pumped to the digester.

Process Description

- Different technology options exist for food waste digestion, specifically dry and wet anaerobic digestion systems are distinguished. Dry digesters are discontinuous because biogas production is sequenced with loading and unloading phases. Several digesters may be operated in parallel to enable semi-continuous processing of food waste and constant production of biogas over time. Wet anaerobic digester are operated continuously; with frequent (typically daily) feeding of fresh material combined with removing digestate. The tank reactor is slowly mixed by the macerator pump and an internal mixer.

Anaerobic means: without oxygen and air. The food waste stays typically 30 to 45 days in the reactor. Bacteria degrade (digest, eat) the organic compounds and convert these compounds into a biogas which is composed of around 55% methane and 45% carbon dioxide (and small amounts of H_2S, water vapour and other compounds). Because of the high temperatures there is no need for further heating the waste (bacteria like higher temperatures). The residue of the digester is a liquid with suspended solids. These solids have escaped the digestion process and are pieces of wood, fibres, and bones. The mixture is called 'digestate'.

- Screw press (or decanter centrifuge) to separate the digestate into a solid fraction and a liquid fraction.
- The liquid fraction is discharged into the municipal sewer or used in a more valuable way (depends on the local situation).
- The solid fraction is transported by a truck to a composting plant: the solid fraction is still too wet (25% dry matter) and cannot be composted alone because it lacks easily degradable compounds that are required to heat up the compost pile. Therefore, it should be mixed with fresh organic material and composted together: usually 50% digestate solid fraction and 50% fresh material. This fresh material can be other organic waste than market waste.
- Storage tank for solid fraction.
- The biogas is cleaned in a column e.g. in bio scrubber (for H_2S removal) and is dried (by cooling)
- A gas holder to store the biogas: as a buffer between biogas production and biogas utilization.
- An electricity generator to produce electricity. Such generators have an efficiency of around 35%: 35% of the energy in the biogas is converted into electricity, the other 65% into heat. Therefore, a local application of hot air would be welcome.
- A flare in case the biogas production is higher than the consumption by the generator: in emergency situations.

Visuals

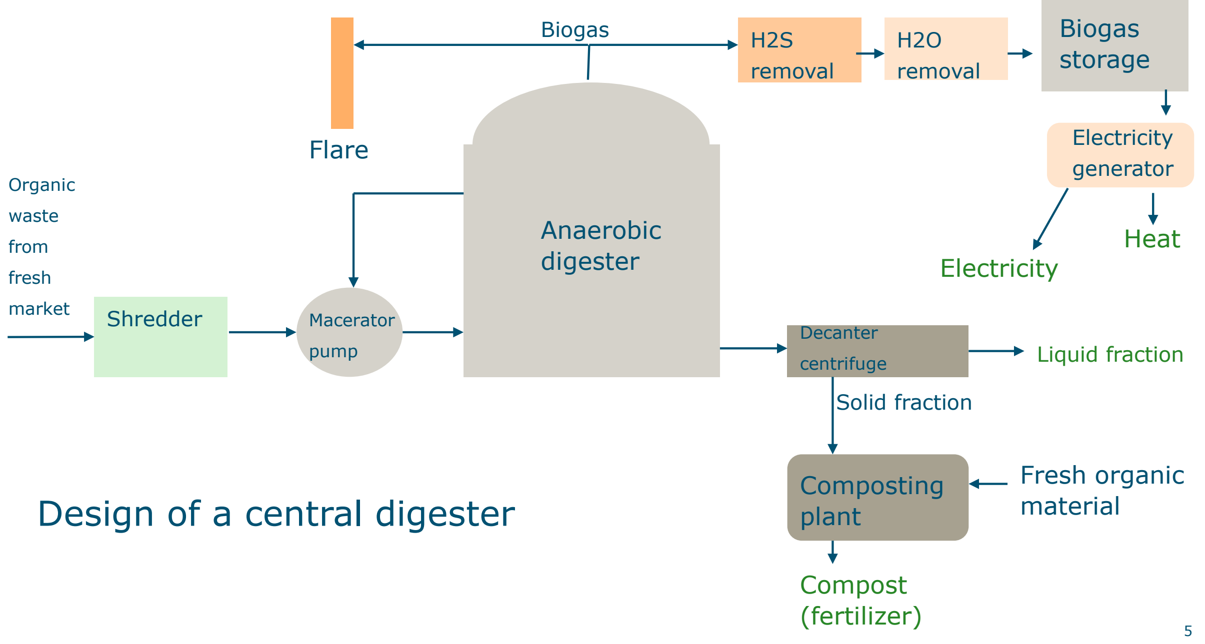


Figure 12 Design of a central digester.

Business Case

There are two options: decentral biogas plants and central biogas plants.

- A small decentral biogas plant near one single fresh market: may have a capacity of 10 tonnes fresh market waste (organic fraction) per day. Such decentral approach avoids the transportation of the market waste to a central plant far away. Only the solid fraction of the digestate have to be transported, but these are amounts in an order of magnitude lower than the fresh waste.
- A central digester has more economy of scale; but more transport is required. Think of capacities of 100 tonnes fresh waste (organic fraction) per day.

In a project to design a central digestion system for fresh market waste in Dhaka (Bangladesh) we estimated:

- Volume digester: 4,881 m³
- Biogas production: 6,447 m³/day
- Nett electricity production: 444 kW
- Heat production: 1,053 kW
- Digestate liquid fraction: 77.4 m³/day
- Solid fraction of the digestate (wet fresh weight): 11.3 tonnes/day (25% dry matter content)
- 21% of the original dry matter ends up in the solid fraction
- Investment costs: around 1 million US$

The investment costs were estimated with local suppliers of equipment in mind.

The annual costs are the due to collection of the waste (labour), transportation of the waste to the central plant, financing, maintenance of the biogas plant and labour at the biogas plant. The energy required to run the plant already is subtracted from the energy produced (biogas, electricity). Electricity is the main revenue. This was compared with the current landfill costs (also including collection and transport). The result is shown below.

		DBT*/year
Market waste	Collection	52,286,000
	Transport	25,550,000
Biogas plant	Labour	2,160,000
	Maintenance (3% of CAPEX)	3,079,000
	Financing (8% of CAPEX)	8,211,000
TOTAL COST		91,286,000
Revenues	Electricity	33,502,000
Nett costs of waste management		**57,784,000**
Current costs		**87,600,000**
Payback period: 3.4 years		

* Bangladesh Taka: 1 DBT ~ 0.0095 US$ ~ 0.175 Mexican Peso

According to above analysis producing biogas from market waste is more cost-effective than landfilling. The annual revenues from electricity are higher than the annual costs of the biogas plant, but not enough to counterbalance the costs involved in collection and transport. A fee per tonne waste still is necessary to make this possible. In Mexico cost and revenue prices may differ from those in Bangladesh. Maybe subsidies are available as well.

The main challenges is setting up the supply chain. One missing link means failure. The waste segregation should be organized, the waste feed should be rather constant, waste composition should be adequate, permits and capital are required for constructing a biogas plant, the biogas should be sold and the digestate should get a destination. Local suppliers of biogas plants and service providers should be available. How to get a fee for every tonne of waste?

Environmental sustainability impact

This intervention contributes to reducing environmental sustainability at system level:

- The traditional waste management – landfilling – induces high GHG emission (typically 1.6 kg CO2-eq. per kg food waste, see EPA (2018)).
- Composting scores better, since methane emissions can be prevented; instead the compost contributes to fixing carbon in the soil.
- Biogas digestion (optionally followed by composting) further enhances the positive effects: nutrients are better conserved in anaerobic digestion than composting; when applied to the soil these nutrients replace synthetic fertilizer which induces substantial greenhouse gas emissions. Furthermore, the produced electricity replaces electricity on the grid (which is largely derived from fossil energy). EPA (2018) estimates the bioenergy yield of a typical food waste stream at 195 kWh per ton waste.

The actual size of the effects depends on the food loss material properties.

Examples/Links
Dedicated biogas plants for the conversion of fresh market waste to biogas are rare, in most countries market waste is mixed with all other organic waste from municipalities (source separated organics; SSO; In Dutch GFT) and digested in biogas plants. In the Netherlands at least ten large biogas plants for biogas from SSO are active. Designers/constructing companies are a.o. OWS (Gent, Belgium) and Kompogas (Switzerland).

An example of a dedicated decentral biogas plant for fresh market waste is the biodigester in Bowenpally, Hyderabad, India. This plant has been started a few years ago. It is constructed near a food market and it is processing food market waste. In this plant, the waste is shredded, then it is soaked in a Feed Preparation Tank to be converted into a slurry. This undergoes an anaerobic bio-methanation process using a special culture (bacteria consortium). Finally, in separate tanks, the biogas is collected and directed to the kitchen for cooking. The biofuel is supplied into a generator which powers water pumps, cold storage rooms, street, and shop lights. The reactor is an anaerobic gas lift reactor, as invented and patented by CSIR-IICT (Indian Institute of Chemical Technology). The project was a government project under the Swachh Bharath Mission Initiative. The plant was constructed by Ahuja Engineering Services (Hyderabad). More such plants are under construction now. Please see the video: https://www.youtube.com/watch?v=Dz5pPFi4c1I

Suggested Next Steps
Estimation costs and benefits under Mexican conditions. Ask opinion of the problem owner (city corporations).

3.4. Conclusions

Above the decision tree for food loss valorisation is illustrated by two food loss streams at CEDA market: oranges and tomatoes. The tomato waste appears too low quality for food or feed application, upgrading the waste management, like biogas fermentation or possibly feed for insects, seems the best possible option. For surplus/rejected oranges higher value applications (including options for food, feed, and non-food application) were identified. Descriptions are provided for the proposed valorisation pathways. We recommend to further explore entrepreneurial enthusiasm for these.

4. Identification of Food Loss causes and Interventions at the supply chain level

The Identification of Food Loss Causes and Interventions at supply chain level consists of the following steps:

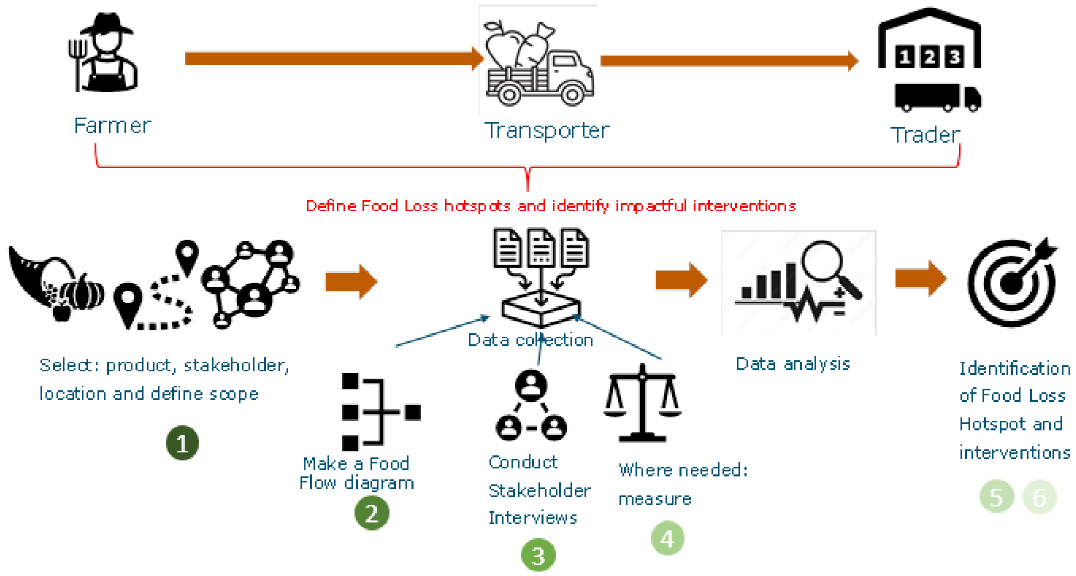
1. The **Scoping phase** consists of a questionnaire to decide the scope of the research. What part of the supply chain is included and what part is out of scope?

2. The **Food Flow phase** consists of a set of questions for expert interviews to list supply chain actors, their activities, flow weight and destinations.

3. In the **Focus phase** flows are scored on five criteria that are used for identifying the FL hotspots.

4. The **Measurement phase** is an optional phase and can be included when new or more precise food loss data is desirable.

5 & 6. The **Cause and Intervention phase** consists of an investment space calculator to determine upper bounds for potential investments. It is aimed at identifying interventions and assessing their feasibility and impact.



4.1. Introduction

FLW is a complex phenomenon that arises from inefficiencies in the food supply chain but also from poor infrastructure. Inefficiencies can occur at any stage of the supply chain, from harvesting to processing, packaging, transportation, storage, and distribution. Poor infrastructure, such as inadequate roads, storage facilities, and power supply, can also contribute to FLW by causing spoilage or loss of perishable food items. Reducing FLW requires an understanding of what happens in the chain.

Multiple approaches to accessing FL in the food supply chain, and various FL protocols are available. Typically, quantities of FL are estimated through literature reviews and/or measurements. However, in literature only limited reliable data on FL can be found and FL measuring throughout the supply chain is time-consuming and costly. In a business setting with limited resources, a balance must be made between the level of detail and reliability of quantification and the practicality of collecting primary data. Primary data collection is not an end in itself. It should lead to determine where and how to implement improvements to existing processes.

In response to this dilemma Wageningen Food & Biobased Research (WFBR), as part of the Consortium for Innovation in Post-Harvest Loss & Food Waste Reduction, developed a new FL quantification methodology, the EFFICIENT protocol (EFFectIve food Chain IntervENTion). The EFFICIENT protocol is a FL quantification tool designed as an accessible, pragmatic, and solution-focused methodology that can quantify and address FL while remaining robust, reliable, and comparable for reporting and tracking progress towards Sustainable Development Goal (SDG) Target 12.3. By using the EFFICIENT protocol, users can gain a better understanding of their role within the food system and reduce the time required to implement effective FL-reducing interventions. It is an intervention oriented quantification methodology that follows the Target → Measure → Act approach, is less labour-intensive, less costly, and more easily adopted and implemented than many existing tools while remaining reliable and suitable for reporting and tracking progress towards SDG Target 12.3. The methodology uses existing data and knowledge strategically and supplements it with targeted primary data collection as necessary. Additionally, the EFFICIENT protocol helps identify FL hotspots and their causes, prioritizing appropriate interventions to accelerate the time to impact [4].

After considering CEDA's objectives and circumstances, the WFBR project team came to the conclusion that the use of the EFFICIENT protocol is very suitable for this project. The EFFICIENT methodology was customized to CEDA's situation.

The approach consists of 6 Phases (Figure 13, Appendix 8 for link to the EFFICIENT protocol) that are interconnected and sequential. The result of the Scoping phase is the starting point for the Flow phase, the result of the Flow phase is the starting point for the Focus phase, etcetera. Only the Measurement phase can be applied in different moments in time. For example, after the Flow phase when more reliable data is desired, after the Focus phase when more precise data is aimed, or after the Intervention phase when a more detailed analysis is wanted to decide upon the best intervention to implement.

Using the EFFICIENT protocol, we conducted an analysis of the supply chain within the specified scope. This involved guiding data collection, using data-driven methods to select hotspots, identifying root causes, and suggesting appropriate interventions. To aid in finding the root causes and providing suitable interventions, we utilized the cause tree and intervention tool (which can be accessed via Appendix 8). We recorded videos during the explanation of the EFFICIENT Protocol, which can be revisited at any time. Additionally, we created questionnaires specifically designed to collect the necessary data for the analysis. To physically measure losses at arrival at CEDA, we developed a measurement protocol to assist with data collection.

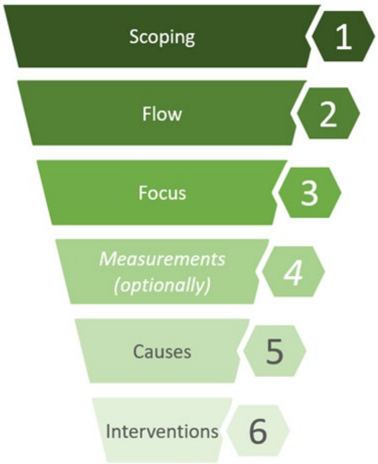


Figure 13 The 6 successive phases of the EFFICIENT Protocol.

Additionally, we captured observations during the assessment, particularly during field visits and measurements, by taking photographs. This approach helped to visually illustrate the supply chain and the causes of food waste.

The upcoming chapters, will provide a detailed description of these 6 phases as well as the definition of starting point, drawing on real data collected at CEDA and going though all 6 phases of the protocol.

4.2. Phase 1: Scoping

The primary objective of the Scoping phase is to establish the scope of the user's EFFICIENT study. In this phase all starting points are defined. It identifies for instance the most promising product(s), determines the definitions that would be employed during the assessment, specifies the goal to be achieved and the level of detail required to accomplish the goal. The Scoping phase also delineates the segments of the supply chain that are within and outside the scope, thereby defining the boundaries of the supply chain or network, and determines the geographical regions, level of product detail, and time frames to be considered. The Scoping phase involves a questionnaire that helps to determine the boundaries [4].

To identify the most promising product the assessment team considered three main criteria:

1. The product had to be among the top 10 traded products in the market, indicating its economic significance.
2. It had to have significant food losses, meaning that there was a significant opportunity to reduce waste and improve efficiency.
3. The involvement of a 'problem owner,' such as a wholesaler, was necessary to ensure the assessment's success.

Based on these criteria, the assessment team selected white onions and tomatoes for evaluation. While WFBR evaluated the white onions, CEDA planned to assess the tomatoes at a later stage, using the same methodology.

Regarding the applied FLW definition, the assessment team opted to use the definition provided in Chapter 1, Introduction. However, the team also decided to include economic losses, the reduction in market value due to decreased quality, in the assessment. For the onion supply chain, the traders involved defined their goal as "decreasing (economic) food loss and waste and calculating investment space for investment". With reference to the level of detail required to meet the goal it was specified that it was sufficient to have annual averages for the assessment.

Two onion Wholesalers at the CEDA market showed interest in reducing FL and economic losses in the white onion supply chains were identified. To better understand their needs and goals, the scoping template (Figure 14 and Appendix 9) was completed. This information was gathered through a questionnaire and interviews.

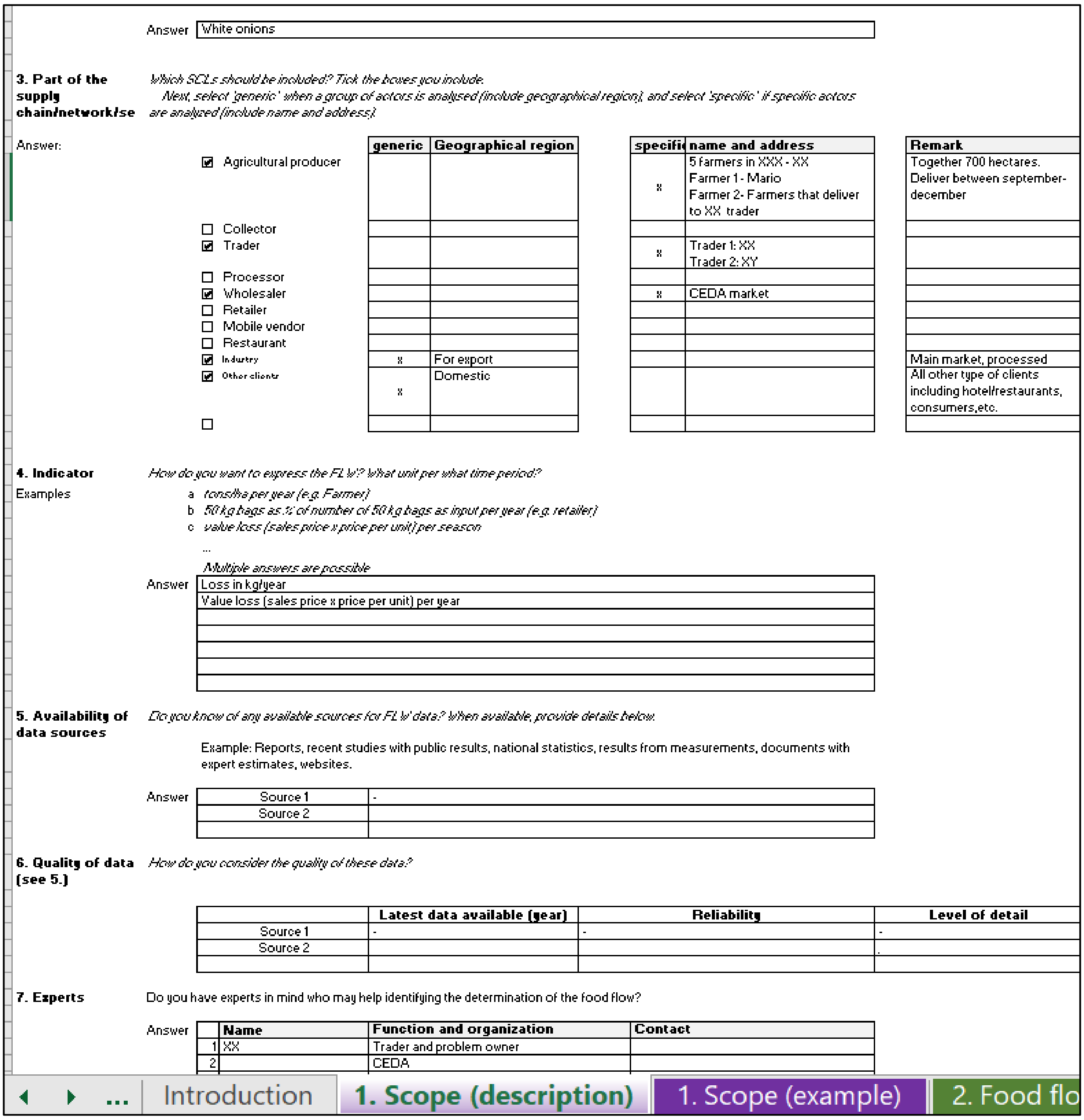


Figure 14 Scope (description) Onion (source: print screen EFFICIENT).

4.3. Phase 2: Flow

The objective of the Food Flow phase is to gain a comprehensive understanding of the supply chain in question including food loss hotspots [4]. The result is a food flow diagram that displays the selected supply chain (Figure 16) and a table that shows the residual flow volumes and percentages, the destination of the residual flows, the sales volume, and so on (Figure 17). To acquire this information a questionnaire per chain stakeholder (Figure 15, Appendix 10) was developed and filled in by selected stakeholders (traders, producers, experts) for the onion supply chain. The questionnaire for data collection is available in English and Spanish language and the questions are divided per type of actor.

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CEDA Questions for Flow Phase 2: Definition of product and residual flows

The questions are aimed to identify the FLW hotspots and mitigation options, and at understanding the product flows, inputs and residues from the supply chain. Global layout of the supply chain must be supplied by local actors/experts. For quantitative data we have the following preferences:

- preferably the data are actual (average) values given by an actor
- if that's not available, an expert may provide an average or expert guess
- final option is that WUR estimates the values (based on secondary data).

Information requirement

Agricultural producers

Name producer(s):
Date of interview:
Location:

Production

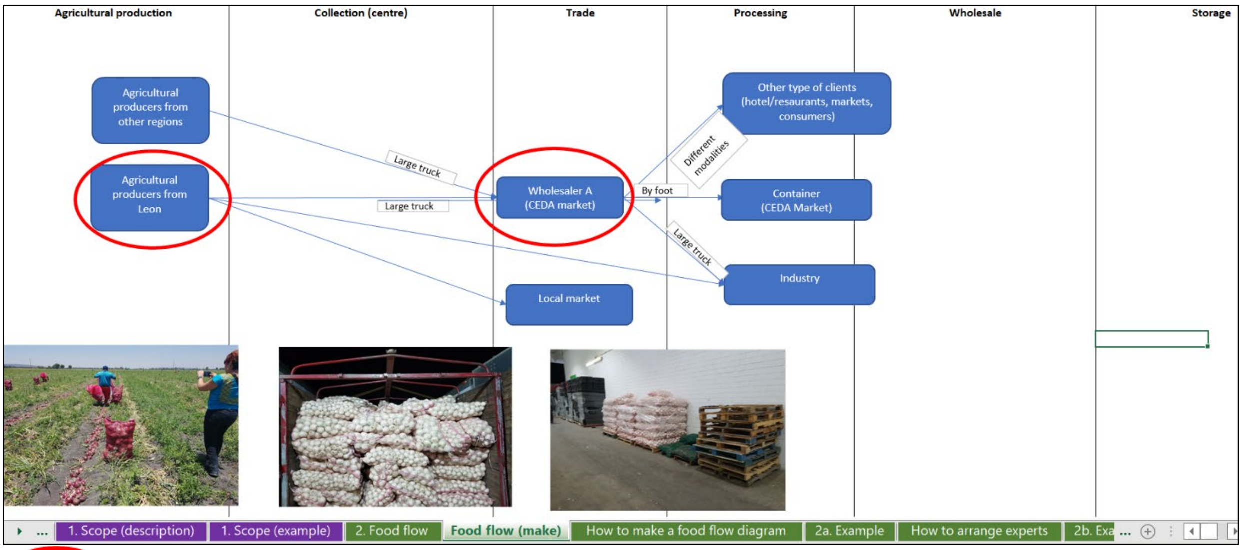
1. What is the size of the production field for this crop? How do you decide upon the size of the production area?
2. Do you produce based on contracts with buyers? Please explain.
3. What problems do occur during the production of the specific product?

Harvest

4. What harvest tool(s) do you use?
5. What is the expected yield per hectare?
6. How many production seasons are in one year? Calculate total yield per year.
7. What problems do occur when harvesting?
8. What % of the product do you estimate was left in the field 'unharvested'? (include unharvest product,

Figure 15 Questionnaire to gather data.

Thereafter the gathered information was analysed (Appendix 11) and validated in a field trip to evaluate the supply chain and discuss with relevant stakeholders. This resulted in the visualized onion supply chain from production till arrival at CEDA for the onions as well as the residual flows (Figure 16 & 17, Appendix 12).



Actors in scope

Figure 16 Food Flow Onions from producer to trader (source: print screen EFFICIENT protocol).

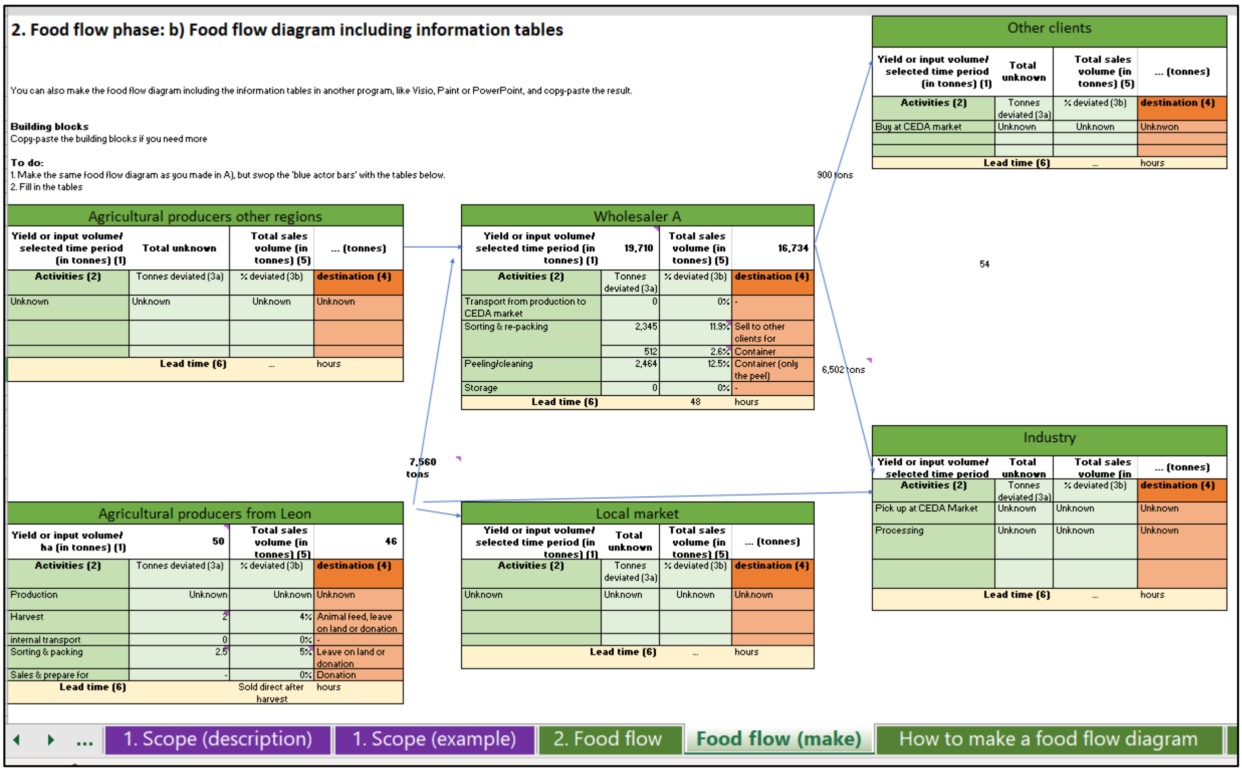


Figure 17 **Residual overview from producer to trader (source: print screen EFFICIENT protocol).**

4.4. Phase 3: Focus and Phase 4: Measurement

The objective of the Focus phase is to prioritize chain stages or activities that are deemed to be the most critical and promising for reducing food losses. The outcome of this phase is an overview with a ranking of chain stages or activities that are considered the most pressing and potential for reduction. Data on these criteria can be obtained from the Food flow phase, as well as client or expert consultation, or other sources considered as relevant. The objective of the Measurement phase is to verify the accuracy of expert estimates when there is uncertainty, lack of data, or when more accurate information is required [4].
In the context of the onion supply chain it was decided that measurements at the level of the market are relevant to obtain more reliable data on market losses and determine investment opportunities. Measurements were completed in the CEDA case before the data analysis of the Focus phase. However, in other scenarios with different goals, skipping the measurement phase and proceeding directly to phase 5, the Causes analysis, may be decided upon.

A cost efficient and straightforward measurement protocol was developed. The measurement protocol can be used to measure the amount of onions that arrive at CEDA, and to measure the amount of economic losses and food losses. The traders themselves are expected to perform the measurements and complete the protocol. The protocol comprises three sections: 1) instructions for measuring, 2) a table for data entry, and 3) a table for analysis. (Table 16, Appendix 13). The protocol requests for measurements by at least 2 CEDA sellers for minimal three days. The instruction was to take 20 bags out of the truck and select good onions and bad onions, weigh them, weigh the waste and the sales for lower price weight.

Table 16 Onion measurement protocol CEDA market sellers.

Onion measurement protocol CEDA market sellers

1. Instruction: Take 20 sacks out of the truck and select the good and bad onions, weigh them, weigh the waste and sell at a lower price. Please also tell us what the purchase and sales price value is.

1. Instrucion : Sacar 20 sacos del camión y seleccionar las cebollas buenas y las malas, pesarlas, pesar los desperdicios y las ventas a menor precio. Por favor, también díganos el valor del precio de compra y venta.

2. Data entry: Measurements

Product	Date	Weight of 20 bags kg	Onion in good condition kg	Onion in poor condition kg	Waste for container kg
PRODUCTO	Fecha	Peso de 20 sacos kg	Cebolla en buen estado kg	Cebolla en mal estado kg	Desperdicio para contenedor kg
Purchase price					
Selling price 1st market					
Selling price 2nd market					
Price Wastebin					

3. Data analysis

Total	Sale 1st market (no waste)	1st %	Sale 2nd market (economic loss)	2nd %	Sale waste (food waste)	% waste to wastebin	Confirmation
Total	Venta 1ra		Venta 2da		Desperdicio	% desperdicio	Confirmación
0	0	#DIV/0!	0	#DIV/0!	0	#DIV/0!	**0,00**

Table 17 and Table 18 present the findings from the measurements and data analysis. On average, 86% of the onions were classified as first class, 12% as second class, and 3% were discarded as waste. Although the percentage of waste is relatively low, the economic losses are substantial.

Table 17 Results data entry measurement onions.

Date	Weight of 20 bags supply (kg)	Onion in good condition (kg) (sale 1)	Onion in poor condition (kg) (sale 2)	Onion loss for container (kg)
6/8/2022	700	595	80	25
6/9/2022	708	615	78	15
6/10/2022	694	590	90	14

Table 18 Results data analysis onions.

20 bags (kg)	Sale 1 (kg)	Sale 1(%)	Sale 2 (kg)	Sale 2(%)	Loss (kg)	Loss(%)
700	595	85.0%	80	11.4%	25	3.57%
708	615	86.9%	78	11.0%	15	2.12%
684	590	86.3%	90	13.2%	14	2.05%
Average		*86.1%*		*11.9%*		*2.6%*

Table 19 combines the results of the measurement data analysis with the expert interviews and show per activity the FLW in tonnes, percentages, and monetary values. The results provide informed directions, but are not exact after the decimal point. Results for the activities for the Agricultural producer are based on interviews, those for the Wholesaler A are mainly based on the 3 days of measurements and are confirmed in the interviews. At the level of the agricultural producers per harvest and ha four tonnes of onions are lost. This is equivalent to 9 % of the harvested onions and equivalent to a sales value of 21,250 Mexican Peso/ha (equivalent to approximately 1,063 US$/ha[10]). At the level of the selected CEDA wholesaler the amount of onions sold to lower markets and lost and wasted is per year approximately 5,300 tones and represents a sales value of approximately 7,400,000 Mexican Pesos per year (equivalent to approximately $370,000 USD annually). This is a significant amount of money, and equivalent to the maximum potential benefit (Table 20). It may not be possible to eliminate all of these losses, a more realistic scenario might be 50 % reduction which still represents a significant economic benefit, approximately 10,600 Mexican Peso/ha and harvest for the agricultural producer and approximately 3,700,00 Mexican Peso/year for the Wholesaler A (Table 20).

Table 19 FLW per activity in: tonnes, percentages, and monetary values.

Name actor	Activities	Destination	FLW weight weight tons		weight %	Potential annual benefit Mexican Peso/year		US$/ha - US$/year	
Agricultural producers from Leon	Production	Unknown	Unknown		Unknown	Unknown		Unknown	
	Harvest	Animal feed, leave on land or donation	2	tons/ha	4%	8,750	Mexican Peso/ha	438	US$/ha
	Sorting & packing	Leave on land or donation	3	tons/ha	5%	12,500	Mexican Peso/ha	625	US$/ha
	Sales & prepare for transport	Donation	0	tons/ha	0%	0	Mexican Peso/ha	0	US$/ha
		Total agr. Producers	4	tons/ha	9%	**21,250**	**Mexican Peso/ha**	**1,063**	**US$/ha**
Wholesaler A	Transport from production to CEDA market	-	0	tons/yr	0%	0	Mexican Peso/yr	0	US$/yr
	Sorting & re-packing	Sell to other clients for lower price	2,345	tons/yr	12%	3,518,235	Mexican Peso/yr	175,976	US$/yr

[10] The *employed exchange rate is 0,050*

		FW Container	512	tons/yr	3%	3,843,450	Mexican Peso/yr	192,243	US$/yr
	Peeling/cleaning	FW Container (only the peel)	2,464	tons/yr	13%	0	Mexican Peso/yr	0	US$/yr
	Storage	-	0	tons/yr	0%	0	Mexican Peso/yr	0	US$/yr
		Total Wholesaler A trader	5,322	tons/yr	27%	**7,361,685**	**Mexican Peso/yr**	**368,219**	**US$/yr**

***Table 20** Potential maximum and realistic benefit reducing FLW.*

Hotspots	Maximum potential benefit when reducing FL with 100% (rounded)	Realistic potential benefit when reducing FL with 50% (rounded)	Indicator
Agricultural producers from Leon	21,250	10,600	Mexican Peso/ha
Wholesaler A	7,362,000	3,700,000	Mexican Peso/year

One of the critical factors that determine the quality of a product is the production and harvest process. Therefore, it is recommended that efforts to improve product quality should primarily focus on the agricultural producers. By improving the quality of products at the farmer level, the overall quality of products in the market would significantly increase, resulting in reduced (economic) losses for the wholesalers. This would also help to reduce peeling losses as improved quality would require fewer parts to be peeled off. In the above calculations the reduction of peels not yet taken along. Currently, peel waste accounts for 13% of the total waste. A 50% reduction due to better quality would have a considerable impact on the wholesaler's revenue. It is therefore essential to recognize the vital role that agricultural producers play in the quality of products and the potential impact that targeted interventions could have on the entire supply chain.

4.5. Phase 5: Causes

To determine the most appropriate and effective interventions to address FL reduction, it is essential to first understand the underlying causes. In the Cause phase the root cause(s) of FL are identified and prioritized [4]. The Cause tree and intervention tool (https://the-efficient-protocol.azurewebsites.net/ and Appendix 8) can be used to support the root cause definition.

To identify the root causes of FL at CEDA Wholesalers, a combination of methods was employed.

1. Firstly, a literature review on good postharvest practices for white onions was conducted.
2. Additionally, WFBR's cause and intervention tool was utilized, resulting in a Cause tree that defines FL root causes (Appendix 14).
3. An expert field visit was also conducted, where the applied practices in the field were observed, and discussions were held with supply chain actors and other experts to understand their problems and applied practices.

During the field trip, it was observed that although the visited producers were highly professional and large-scale, using quality seeds from Argentina, the Netherlands, and the US, and exporting their white onions to the US and other surrounding markets, they did not apply proper curing and drying techniques (such as leaving several inches of neck on the bulb when cutting) for onions supplied to the domestic market. Proper curing would improve the onions' storability and reduce the quality issues later in the supply chain. Additionally, producers received on short notice the demand for supply from the CEDA wholesalers, making it difficult to allow for sufficient time for proper drying and curing.

The Causes analyse resulted in Table 21, a cause table that links observed problems of the Wholesalers to potential causes of FLW. The cause table serves as a guide to help users and interviewed actors identify the root causes of FLW. One of the main quality problems of the onions wholesalers at the CEDA market was inside rot (Figure 18)

Table 21 Cause table relating the problems of the Wholesalers to likely root causes.

Problems of the Wholesalers	Likely root causes of FLW (random order)
Dehydration and shrinkage, ripening issues (maturation), and quality variation	Due to droughts (due to climate change)
Ripening issues (maturation), quality variation, and rots and other quality issues	Due to heavy rains (due to climate change)
Damages at the plant	Due to strong Northern winds
Low demand in high season	Due to peak season
Quality variation	Due to difficulty to determine moment of maturity and no payment for quality
Quality issues such as rots and moulds	Due to high humidity after harvest
Lack of labour and no time to dry harvested produce	Due to short-term planning
Quality problems like inside rot (Figure 18)	Due to lack of knowledge


Figure 18 Example of quality problems due to inside rot.

4.6. Phase 6: Intervention

The objective of the Interventions phase is to identify and recommend interventions that can effectively prevent or reduce FL. This phase involves selecting one or more suitable interventions and considering the perspectives of the relevant actors involved in implementing them.
The Interventions phase comprises two parts:

a) a list of potential interventions
b) decision support.

Ad a) The list of potential interventions offers a range of suitable intervention types based on the root causes identified in the Causes phase. The user can select potential interventions from each type. In cases where multiple interventions are chosen, decision support is necessary to guide the selection process. This section includes three steps designed to assist in determining 1) which criteria are the most significant, 2) which intervention(s) should be selected, and 3) how to create commitment to the chosen intervention(s). By following this structured approach, interventions can be effectively implemented to address the underlying causes of FLW and achieve measurable reductions in food waste [4]. Through the use of an intervention tool (Appendix 8), a comprehensive catalogue of potential beneficial interventions was generated for the chosen white onion supply chain (Table 22).

The hardware interventions underwent a multi-criteria analysis to evaluate their economic feasibility, impact, and feasibility of implementation. The following 3 intervention were selected (based on stakeholder workshop) (See Table 23):

1. Improved storage structure design with ventilation
2. Place a roof
3. Proper ventilation of onions to dry them (curing)

Table 22 Overview of potential interventions and reason for selection.

Potential interventions (random order)	Reason for selection
Maturity indices charts	To determine moment of harvest
Curing before bagging or loading (use proper temperature and ventilation)	To maintain quality of produce
Topping of onions when neck is dry	To maintain quality of produce
Create raised beds with a furrow	To avoid water logging and decrease moisture contact and to maintain quality
Storage facility with roof and ideally as well ventilation (low-, mid-, or high tech)	To keep onions dry after harvesting when raining and to maintain quality, might also open the possibility to prolong the sales window of the farmers & buying window of CEDA traders
Use of low-tech sorting/grading procedures/equipment such as charts to sort on quality beyond size (injuries, firmness, decayed, etc.)	Too much produce is transported and thrown away at arrival at the CEDA market
Train the trainers on harvest- and post-harvest management and food loss reduction	To improve production quality and maintain post-harvest quality
Quality based pricing system (payment based on quality such as injuries, firmness, decayed, etc.)	As driver to invest in quality
Stock certain staple crops to stabilize prize	To stabilize prices
Long term planning of traders & ordering in advance	Enable proper curing, grading...
Create partnerships with knowledge centres	Focus on climate adapted seeds

Table 23   Selection of the most promising hardware investments.

		1) Storage facility	2) Roof	3) Drying by ventilation
1	**Economic viability: Intervention fits within investment space**	**2.0**	**3.0**	**3.0**
	a. Affordability	1	3	3
	b. Resource availability/accessibility	3	3	3
2	**Impact: Contribution of this intervention to reducing FLW**	**2.7**	**2.3**	**2.7**
	a. Scalability	3	3	2
	b. Time to impact	3	3	3
	c. Impact of the intervention	2	1	3
3	**Applicability: Intervention is realistic in the context/case**	**2.8**	**3.0**	**2.4**
	a. Acceptability	3	3	3
	b. Awareness	3	3	2
	c. Usability	2	3	1
	d. Availability of extension services	3	3	3
	e. Participatory approach	3	3	3
	Final score, highest has most preference	**7.5**	**8.3**	**8.1**

Ad b) Decision support

- The preferred intervention selected by the stakeholders was to install a roof; however, it was advised by the WFBR experts that the impact on reducing FL would be minimal without combine the roof with an elevation to keep the onions dry and ensure proper drying and curing. Often additional activities need to be arranged to ensure the success of an intervention.
- The next preferred intervention was to shift from drying and curing in the field to using a shaded area, room, or greenhouse with bulbs laid out in trays or racks in a covered, and well-ventilated space. This approach has the advantage of improving bulb quality, reducing vulnerability to rain, and minimizing losses. However, it also incurs additional costs
- Thirdly, a suitable storage facility was chosen, which would need to be accompanied by the aforementioned proper post-harvest management practices. This intervention requires more investment compared to the other two selected interventions. However, a proper storage facility has the potential to significantly extend the current sales window.

Regarding the needed investment, we learned from the Focus and Measurement phase, that the potential annual investment space for onions in the selected supply chain is substantial, around 10,600 Mexican Peso per hectare for the agricultural producer and approximately 3,700,000 Mexican Peso per year for the wholesaler.

Based on the assessments the advice of the WFBR experts was:

- To start curing before bagging and loading,
- To install storage facility with roof and ideally as well ventilation,
- To train on harvest- and post-harvest management and food loss reduction,
- That traders make a long term supply planning and order in advance.

As a first step, we suggest building data-driven evidence to prove the effectiveness of the intervention through a pilot program, potentially with the support of the Ministry of Agriculture. A selected farmer could apply the suggested intervention to a portion of the harvested onions, and the impact should be monitored. If the pilot is successful, the intervention could be scaled up to other farmers and regions. To begin, the most promising supply chain could be a vertically integrated supply chain. Some wholesale traders are also producers or have family members supplying the produce, making it an interesting starting point as they would directly benefit from the investment at the producer level.

4.7. Explanation Videos

There are a total of eight instructional videos that provide a detailed explanation of the EFFICIENT Protocol methodology. Each video focuses on a specific phase of the protocol, with the first video serving as an introduction and the last video concluding the series. By selecting the link below, you can access each video and learn about the various phases of the EFFICIENT Protocol, including their respective procedures and best practices.

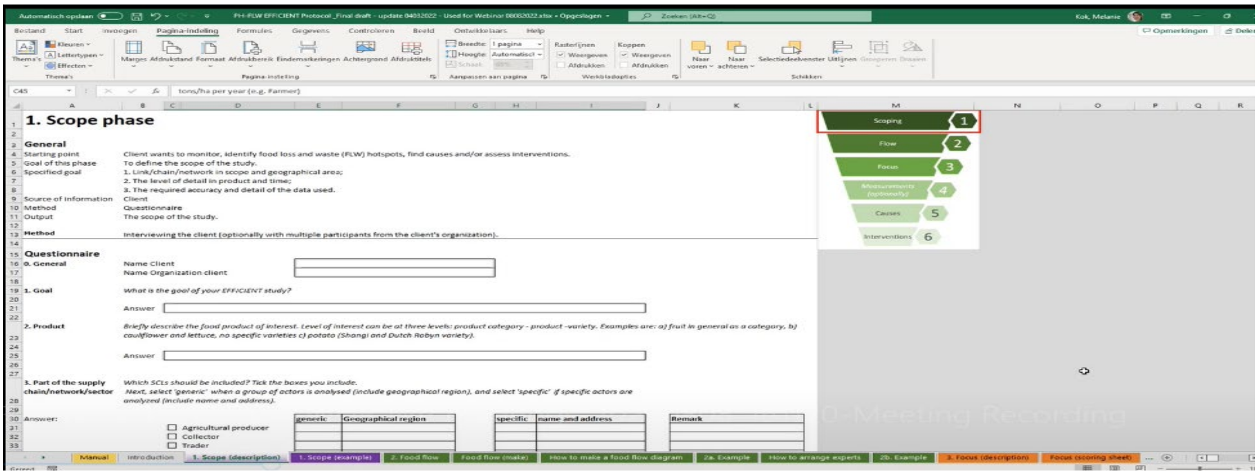


Figure 19 Explanation of the EFFICIENT protocol.

Links to the video clips

1. Video clip giving an **Introduction to the EFFICIENT approach**
   https://youtu.be/0pq9UYS4G0M

2. Video clip explaining the **Scoping phase**
   https://youtu.be/bI1-xzOzEhM

3. Video clip explaining the **Flow phase**
   https://youtu.be/aaEPBgbz57M

4. Video clip explaining the **Focus phase**
   https://youtu.be/Y4K4GK3sXUo

5. Video clip explaining the **Measurement phase**
   https://youtu.be/8Cc57VMVH1k

6. Video clip explaining the **Causes phase**
   https://youtu.be/dHbfC30RbtM

7. Video clip explaining the **Intervention phase**
   https://youtu.be/mhR-G333xL

8. Video clip with some **Closing words**
   https://youtu.be/fxZiDI0EATY

4.8. Conclusions

In our analysis of preventing food loss in the supply chain. The proposed interventions are at different chain stages than the wholesale market. Specific: we have identified significant potential for investment in white onions within the selected supply chain. Agricultural producers stand to gain at least around 10,600 Mexican Peso per hectare, while wholesalers can potentially benefit by approximately 3,700,000 Mexican Peso per year. This presents numerous opportunities for improvement, including implementing curing before bagging and loading, installing storage facilities with roofs and ventilation, providing training on harvest and post-harvest management, and encouraging traders to engage in long-term supply planning and order placement.

5. Discussion and suggested next steps

Development of Food loss Measurement Protocol

The primary objective was to gain insights into the extent of food loss at CEDA. Through conducting pilots with tomatoes and oranges, a protocol was developed to address two key aspects: firstly, it allowed CEDA to obtain accurate measurements of weight and value loss per product, and secondly, it took into consideration the practical conditions at CEDA-Operations in terms of waste management. Upon implementation of the protocol, it was observed that although the absolute weight of losses was high, the losses were relatively low when compared to the overall supply to the CEDA market.

In the case of tomatoes, during the lean season, the food loss at CEDA amounted to 15,921 kg per day (weighted average), which represented 1.0% of the total supply. In the peak season, the daily food loss decreased to 2,942 kg, equivalent to 0.3% of the supply. The corresponding value losses for tomatoes at CEDA were estimated to be 184,562 MXP per day during the lean season and 65,430 MXP per day during the peak season.

For oranges, the food loss in May was measured to be 2,734 kg per day (weighted average), which accounted for only 0.1% of the total supply. The value loss for oranges at CEDA in May was estimated to be 22,090 MXP per day.

The protocol developed for the CEDA team has proven to be effective and has been recently implemented for oranges for the second time. CEDA plans to extend the application of the protocol to measure food loss for other products as well. If the outcomes for these products fall within the same percentage range, reducing food loss may not be the top priority. However, given that the volumes of loss remain substantial, the focus should be on optimizing the utilization of these losses, preferably by finding opportunities for human consumption or exploring other viable business cases.

To further enhance the accuracy of food loss data, it is recommended to initiate the monitoring of incoming flows, including product type, weight, and the vehicles used. This information is not only valuable for measuring food loss but also crucial for future improvements in CEDA's logistics and infrastructure development.

Valorisation of food loss streams

A decision tree was presented for identifying options for food loss valorisation. To keep it accessible, the proposed approach is kept lean and mean. Depending on the actual quality/safety status of a food loss stream, the decision tree guides towards exploring application for food, feed, or biobased application or to upgrading food loss management.

The decision tree is illustrated by two products, pointing at potential upgraded valorisation. Based on the identified/measured food losses it was concluded that although the volume of food losses is very large, though the percentages of actually traded food are limited. Consequently, in the (narrow) scope of the market, food loss valorisation is considered more adequate than food loss reduction. The tomato loss stream appears too low quality for food or feed application, upgrading the food loss management, like biogas fermentation or possibly feed for insects, seems the best possible option. For surplus/rejected oranges higher value applications (including options for food, feed, and non-food application) were identified.
Next steps involve selection of valorisation pathway(s) from the proposed options. This process may be led by CEDA in co-operation with entrepreneurs. After that a specific business plan may be developed and evaluated. Since a valorisation pathway may depend on continuity of supply of the food loss stream, it is recommended to involve current suppliers of the food stream in the evaluations of the plans.

It is recommended to use the decision tree approach for other food loss streams as well.

Identification of Food Loss Causes and Interventions at supply chain level

To reduce FL, it is important to have a comprehensive understanding of the causes of loss in the food supply chain. This involves identifying the specific inefficiencies and deficiencies that contribute to FL. Once these causes are identified, targeted interventions can be developed and implemented to address them. For example, if food is being lost due to inadequate postharvest management like curing, storage or transportation, investments in improved postharvest processes and facilities may be necessary. Effectively tackling FL in the food supply chain from the producers to the CEDA trades requires multi-faceted and cooperative efforts among the chain stakeholders. Together they have to discuss and implement targeted interventions to address the underlying causes of losses and waste.

In the FL assessment of the onion supply chain, we have identified significant investment space for FL reduction. Agricultural producers stand to gain at least around 10,600 Mexican Peso per hectare, while wholesalers can potentially benefit by approximately 3,700,000 Mexican Peso per year. This presents numerous opportunities for improvement, including implementing curing before bagging and loading, installing storage facilities with roofs and ventilation, providing training on harvest and post-harvest management, and encouraging traders to engage in long-term supply planning and order placement.

To take the first concrete step towards realizing these improvements, we recommend building data-driven evidence through a pilot program that demonstrates the effectiveness of the proposed intervention. The Ministry of Agriculture could potentially provide support for this pilot program. In the program, a selected farmer should apply the suggested intervention to a portion of their harvested onions, and the impact of these interventions should be monitored. If the pilot program is successful, the intervention should then be scaled up to other farmers and regions.

To begin, the most promising supply chain for this pilot program could be a vertically integrated supply chain. Some wholesale traders are also producers or have family members supplying the produce. This would make it an interesting starting point for implementation, as they would directly benefit from the investment at the producer level. Through this strategic approach, CEDA and CEDA traders can work towards reducing food loss in the onion supply chain, while also maximizing the economic potential for all stakeholders involved.

Overall
The approaches developed and described for measuring, valorisation and prevention of food losses can be expanded and applied to other food products as well, even dry products or composite products from various ingredients. These food chains may look different and have more chain links, which should then also be included in the analysis. By leveraging the same principles and strategies presented in this toolkit, other food products can also benefit from improved efficiency, reduced losses, and enhanced profitability. With the growing demand for food products, adopting an effective supply chain management approach is vital for ensuring a sustainable and reliable food supply chain. Therefore, exploring the scalability of this approach to other food products could help to address these challenges and create a more resilient and efficient food system.

It is essential to not only expand the measurements at the market to other food products, but to also prioritize the next phase in addressing valorisation and prevention of food loss in the supply chain. In high-income countries like The Netherlands quality-oriented and demand-oriented food supply chain development was – next to upgrading food quality and consequentially value – critical for minimizing losses in food supply chains. In this development, the holistic view at chain level was essential. For supply to CEDA this involves selecting specific interventions and carrying out recommended measures aimed at reducing losses at CEDA or elsewhere along the chains. To accomplish this, strategic partnerships between "problem owners", investors, entrepreneurs, and supply chain stakeholders should be established by CEDA.

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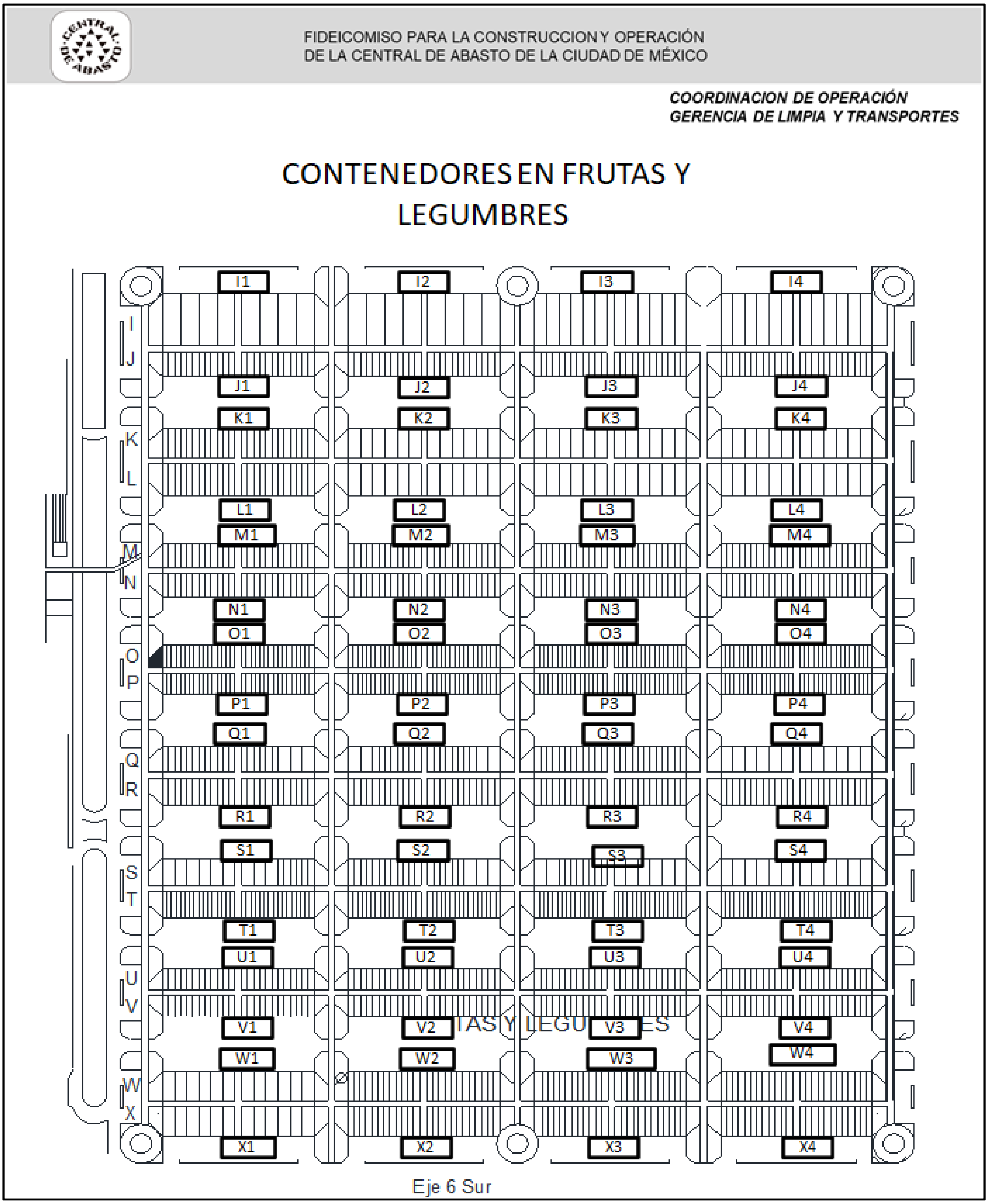
Appendix 1 Valorisation evaluation

Item	Producto	Apto para venta	Separación de componentes con fines de aprovechamiento	Bioreactor	Composta	Biocombustible	Subtotal	Industrias para su valorización	Mayor # de aplicaciones	Bioreactor, composta y biocombustible	Total
		fit for sale	Separation of components for exploitation purposes					Industries for its valorization	Greater # of applications	Bioreactor, compost and biofuel	
1	jitomate	NO	SI	SI	SI	NO	3	3	0	0	6
2	chile verde	NO	NO	NO	NO	NO	2	3	0	0	5
3	cebolla	NO	NO	SI	SI	NO	4	2	0	1	6
4	naranja	NO	SI	SI	SI	SI	4	2	1	0	6
5	plátano	NO	SI	SI	SI	SI	4	2	0	2	6
		SI=0	SI=0	SI = 1	SI = 1	SI = 1			Se asigna 1 al producto con mayor # de aplicaciones	Se asgina un 1 al valor máximo	
		NO = 1	NO = 1	NO = 0	NO = 0	NO = 0			1 is assigned to the product with the highest # of applications	1 is assigned to the maximum value	
		Si no son aptos para su venta como producto fresco, se pueden valorizar	Si se requiere separar sus componentes, implica realizar un preproceso		+						
		If they are not suitable for sale as a fresh product, they can be recovered	If it is required to separate its components, it implies carrying out a preprocess								

	Industrias en la cuales se pueda valorizar	
1	Cebolla	
1	Industria alimenticia	Encurtida, confitada, bioazúcar, fibra, minerales, ácidos grasos, vinagre, conservadores
2	Industria farmaceutica	anticancerígenos, sedantes
2	Jitomate	
1	Industria alimenticia	Semillas: harina, proteína; piel: recubrimiento, colorante, protenína. Residuos del tomate procesado: aditivos
2	Industria faramaceutica	
3	Subproductos de sus componentes	
3	Plátano	
1	Industria alimenticia.	Cáscara: aceite, fibra; pulpa: suplementos alimenticios
2	Industria.	Cáscara: alimento para animales, feritilizantes, enzimas, nanomateriales; completos: bioplasticos, fertilizantes, carbón activado, biofiltros para agua;
		Todo el producto. Biorrefinería / filtros para tratamiento de agua
4	Chile (hace referencia a los pimientos)	
1	Productos farmaceuticos	
2	Productos para el campo	
3	Industria alimenticia	
5	Naranjas	
1	Industria alimenticia.	Pulpa: jugos, azúcar; cáscara: fibra
2	Industria química	Cáscara: ácidos grasos voláties, limoneno (varias aplicaciones), carbon activado, compuestos bioactivos, biosolvente, biopesticidas, celulosa, síntesis de nanoparticulas de plata y óxido de zinc, tinte para tejidos; pulpa: biopolimeros,

Appendix 2 Container map in selected area



Appendix 3 Container evaluation

Date	I1	I2	I3	I4	J1	J2	J3	J4	K1	K2	K3	K4	L1	L2	L3	L4	pictures per day
May 15				-					-				-				1
May 16			T	-							FT						1
May 17			T								-						1
May 18			T	-							-						2
May 19			T	-							-						2/3
May 20			T	-							-						3
May 21																	0
May 22			T	-													1
May 23			T	-													3
May 24			T	-							-						2
May 25			T	-							-						2/3
May 26			T	-							-						3
May 27			T	-							-						3
May 28			T	-							-						1
May 29			FT	-							-						1
May 30			FT	-							-						3
May 31			T	-							-						3
	M1	M2	M3	M4	N1	N2	N3	N4	O1	O2	O3	O4	P1	P2	P3	P4	
May 15													T				1
May 16						-	T	-					T				1
May 17												T	T				1
May 18							-/FT				-		T				2
May 19		FT		-			FT/T		FT				T				2/3
May 20							FT						T				3
May 21																	0
May 22							FT						T				1
May 23							T						T				3
May 24							T						T				2
May 25							T						T				2/3
May 26							T						T				3
May 27							T						T				3
May 28							FT						FT				1
May 29							FT						T				1
May 30							FT						T				3
May 31							T						T				3
	Q1	Q2	Q3	Q4	R1	R2	R3	R4	S1	S2	S3	S4	T1	T2	T3	T4	
May 15					T												1
May 16	T				T	U			T	-							1
May 17	T	T				T											1
May 18	T	T	T		T	T		-	-		-						2
May 19	FT/T		FT		T	T			FT								2/3
May 20	T				T	T			-								3
May 21																	0
May 22	T				T	T											1
May 23	T				T	T			T								3
May 24	T				T	T			-								2
May 25	T				T	T			-								2/3
May 26	T				T	T											3
May 27	T				T	T			-								3
May 28	T				T	T			-								1
May 29	T				T	T			-								1
May 30	T				T	T			-								3
May 31	T				T	T											3
	U1	U2	U3	U4	V1	V2	V3	V4	W1	W2	W3	W4	X1	X2	X3	X4	
May 15														-			1
May 16				-													1
May 17	-	-	-	-	-	-	-	-				-				-	1
May 18			-		-			-	-			-					2
May 19					-												2/3
May 20					-			-				-					3
May 21																	0
May 22																	0
May 23																	0
May 24																	0
May 25																	0
May 26																	0
May 27																	0
May 28																	0
May 29																	0
May 30																	0
May 31																	0

WUR	(shaded) =no picture taken	T= many tomatoes	FT= few tomatoes	U= unclear	- = no tomatoes
WUR/CEDA					-/-= no tomatoes
	(red) = selected container for measurement				

Date	I1	I2	I3	I4	J1	J2	J3	J4	K1	K2	K3	K4	L1	L2	L3	L4	pictures per day
May 15				O/OP					-				-				1
May 16			O	O							FO						1
May 17			-								O						1
May 18			-	O							O/FO						2
May 19			-	O							-						2/3
May 20			-	O							-						3
May 21																	0
May 22			-	O							FO						1
May 23			-	O													3
May 24			-	O							O						2
May 25			-	O							O						2/3
May 26			-	O							O						3
May 27			-	O							O						3
May 28			-	O							O						1
May 29			-	O							O						1
May 30			-	O							O						3
May 31			-	O							O						3
	M1	M2	M3	M4	N1	N2	N3	N4	O1	O2	O3	O4	P1	P2	P3	P4	
May 15													-				1
May 16						-	FO	-					-				1
May 17												OP	-				1
May 18							-				-		-				2
May 19		-		-			-/OP		-				-				2/3
May 20							-						-				3
May 21																	0
May 22							-						-				1
May 23							-						-				3
May 24							-						-				2
May 25							-						-				2/3
May 26							-						-				3
May 27							-						-				3
May 28							-						-				1
May 29							-						-				1
May 30							-						-				3
May 31							-						-				3
	Q1	Q2	Q3	Q4	R1	R2	R3	R4	S1	S2	S3	S4	T1	T2	T3	T4	
May 15					-												1
May 16	-				-	-			-	-							1
May 17	-	-				-											1
May 18	-	-	-		-	-		FOP	-		OP						2
May 19	-		-		-	-			-								2/3
May 20	-				-	-			FO								3
May 21																	0
May 22	-				-	-											1
May 23	-				-	-			-								3
May 24	-				-	-			-								2
May 25	-				-	-			-								2/3
May 26	-				-	-											3
May 27	-				-	-			FO								3
May 28	-				-	-			-								1
May 29	-				-	-			U								1
May 30	-				-	-			O								3
May 31	-				-	-											3
	U1	U2	U3	U4	V1	V2	V3	V4	W1	W2	W3	W4	X1	X2	X3	X4	
May 15														-			1
May 16				O													1
May 17	-	-	-	O	-	-	-	FO				O				-	1
May 18			OP		O			OP	OP			OP					2
May 19					OP												2/3
May 20					O+OP			U				FO+OP					3
May 21																	0
May 22																	0
May 23																	0
May 24																	0
May 25																	0
May 26																	0
May 27																	0
May 28																	0
May 29																	0
May 30																	0
May 31																	0
WUR		=no picture taken			O=	many oranges			FO=	few oranges			U=	unclear		- =	no oranges
WUR/CEDA									OP=	orange peels						-/-=	no oranges
		= selected container for measurement															

Appendix 4 Source data from measurement

Note that the measurements include May 15. Hence 17 days of measurements are shown below.

FIDEICOMISO PARA LA CONSTRUCCIÓN Y OPERACIÓN
DE LA CENTRAL DE ABASTO DE LA CIUDAD DE MÉXICO

COORDINACION DE

SUBGERENCIA DE LIMPIA, TRANSPORTE Y

Control de peso de contenedores. De la contaminación hacia una solución circular.

THIS IS THE CORRECT AND FINAL TABLE. ELIASIB PROVIDED THE FIRST INFORMATION ON MAY 17TH 2022.

CONTENEDOR	PRODUCTO	DIAS Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	Monday	Tuesday	total # days	
		16-mei	17-mei	18-mei	19-mei	20-mei	21-mei	22-mei	23-mei	24-mei	25-mei	26-mei	27-mei	28-mei	29-mei	30-mei	31-mei	17	per day
I3	JITOMATE * 0	0.000	0.000	0.000	1.870	4.310	0.000	2.390	2.730	2.140	0.280	0.000	0.000	0.860	0.000	0.300	0.480	15.360	0.904
K3	NARANJA *0	0.000	0.000	0.680	0.000	0.000	0.000	0.000	0.000	0.000	1.150	0.000	0.000	0.000	0.000	0.000	0.570	2.400	0.141
N3	JITOMATE *0	0.000	0.000	0.170	0.490	0.000	0.000	4.670	0.000	0.000	0.000	0.000	0.350	0.000	0.000	0.000	0.220	5.900	0.347
P1	JITOMATE	4.400	2.330	1.130	1.570	1.490	0.980	3.080	****	2.470	2.170	2.330	1.270	1.060	7.690	1.120	4.580	37.670	2.216
Q1	JITOMATE	5.650	9.070	8.650	5.460	4.550	4.170	5.840	****	8.260	2.470	2.790	5.470	3.310	8.740	2.510	5.810	82.750	4.868
R1	JITOMATE	5.100	4.760	3.080	4.550	6.500	5.640	4.550	5.880	3.260	4.260	4.390	5.660	3.340	3.850	4.860	5.280	74.960	4.409
S1	JITOMATE	6.900	0.000	0.000	0.000	0.000	4.550	0.000	5.630	0.000	0.000	0.000	0.000	5.780	0.000	0.000	0.800	23.660	1.392
I4	NARANJA	1.480	2.540	1.690	4.660	5.230	3.620	1.130	4.430	2.660	3.190	2.030	2.940	2.400	1.140	0.640	4.290	44.070	2.592
R2	JITOMATE * 0*	0	0.750	3.470	2.760	1.000	3.340	1.540	0.000	0.710	0.840	1.180	1.120	0.720	0.000	2.500	3.350	23.280	1.369
	Total	23.530	19.450	18.870	21.360	23.080	22.300	23.200	18.670	19.500	14.360	12.720	16.810	17.470	21.420	11.930	25.380	310.050	18.238
	Jitomate	22.050	16.910	16.500	16.700	17.850	18.680	22.070	14.240	16.840	10.020	10.690	13.870	15.070	20.280	7.660	20.520	259.950	15.291
	Naranja	1.480	2.540	2.370	4.660	5.230	3.620	1.130	4.430	2.660	4.340	2.030	2.940	2.400	1.140	0.640	4.860	46.470	2.734

*0 SE ANTENDERAN CADA TERCER DIA O SI UN DÍA SE TIENE UN VOLUMEN CECANO AL 50% DE LA CAPACIDAD, ESE DÍA SE LLEVA A PESAJE

The weigh will be performed every third day, nevertheless if one day the container has a volume neat to its 50% of capacity, the container will be weighted

0 HASTA EL DIA DE AYER POR LA NOCHE SE HABILITÓ. Included for the WP1 until May 16th 2022.

**** HUBO UN PROBLEMA LOGISTICO Y NO SE PUDIERON RETIRAR LOS CONTENEDORES EL LUNES 23 DE MAYO
There was an logistic issue with the containers. The containers could not be picked up
the container hit another truck, so there was an insure issue

Para los contenedores I3, K3 y N3, se solicitó a los comerciantes arrojar en I3 y N3 el jitomate, y en K3 la naranja.

For I3, K3 and N3 containers, the personal in charge of separting the waste has asked to merchans to drop the tomato into I3 or N3, and orange into K3.

questions about cell values

1 is cell F15 the value of May 16-18? Should F15 be zero?
2 what is the interpretation of the cells G15, I15 and I17? Is I17 including 0.490 from F17?
3 are the cells C15 - C23 for May 15 and May 16 together?

Appendix 5 Wholesale prices CEDA

Here, price data are collected for jitomate. There are several types of prices. You have bulk boxes, and cartons with tomato saladet and tomato bola. In addition, there is difference in quality. Data are presented for both pilot phases

Pilot 1: May 15 – May 31, 2022

In Table 16 the price is for cartons of first quality tomato saladet. These data are used to calculate the value loss for the tomatoes. Note that data for May 15 and after May 19 were not available.

Table 24 Available price data for tomato saladet during the first pilot.

Registros del 01/01/2022 al 19/05/2022						
	Producto		Calidad		Destino	
	Tomate Saladette		Primera		DF: Central de Abasto de Iztapalapa	
Fecha	**Presentación**	**Origen**	**Precio Mín**	**Precio Max**	**Precio Frec**	**avg precio frec (MXP/kg)**
16-5-2022	Caja de 12 kg.	Puebla	$ 160.00	$ 190.00	$ 170.00	14.17
16-5-2022	Caja de 25 kg.	Sinaloa	$ 220.00	$ 280.00	$ 250.00	10.00
16-5-2022	Caja de 13 kg.	Sonora	$ 100.00	$ 140.00	$ 130.00	10.00
17-5-2022	Caja de 12 kg.	Puebla	$ 160.00	$ 190.00	$ 170.00	14.17
17-5-2022	Caja de 25 kg.	Sinaloa	$ 220.00	$ 280.00	$ 250.00	10.00
17-5-2022	Caja de 13 kg.	Sonora	$ 100.00	$ 140.00	$ 130.00	10.00
18-5-2022	Caja de 12 kg.	Puebla	$ 160.00	$ 190.00	$ 170.00	14.17
18-5-2022	Caja de 25 kg.	Sinaloa	$ 220.00	$ 280.00	$ 250.00	10.00
18-5-2022	Caja de 13 kg.	Sonora	$ 100.00	$ 140.00	$ 130.00	10.00
19-5-2022	Caja de 12 kg.	Puebla	$ 200.00	$ 270.00	$ 230.00	19.17
19-5-2022	Caja de 25 kg.	Sinaloa	$ 270.00	$ 350.00	$ 290.00	11.60
19-5-2022	Caja de 13 kg.	Sonora	$ 120.00	$ 170.00	$ 150.00	11.54
					average	12.07

Table 25 Available price info on oranges during the pilot.

Registros del 01/01/2022 al 19/05/2022					
	Producto		Calidad		Destino
	Naranja Valencia mediana		Primera		DF: Central de Abasto de Iztapalapa
Fecha	**Presentación**	**Origen**	**Precio Mín**	**Precio Max**	**Precio Frec**
16-5-2022	Kilogramo	Veracruz	$ 7.80	$ 8.60	$ 8.00
17-5-2022	Kilogramo	Veracruz	$ 8.00	$ 8.70	$ 8.10
18-5-2022	Kilogramo	Veracruz	$ 8.00	$ 8.70	$ 8.10
19-5-2022	Kilogramo	Veracruz	$ 8.00	$ 8.70	$ 8.10
				average	$ 8.08

Source: http://www.economia-sniim.gob.mx/nuevo/

Pilot 2: November 7 – November 21

Precios de Referencia	
Venta de Jitomate	
Precio x kg /mayoreo	Precio x kg / menudeo
$ 23.33	$ 28.00
$ 23.33	$ 28.00
$ 22.50	$ 25.00
$ 22.50	$ 25.00
$ 20.00	$ 25.00
$ 20.00	$ 25.00
$ 20.00	$ 25.00
$ 20.00	$ 25.00
$ 20.00	$ 25.00
$ 21.66	$ 25.00
$ 21.66	$ 25.00
$ 22.50	$ 25.00
*****	*****
*****	*****
*****	*****
$ 25.00	$ 28.00
$ 25.00	$ 28.00
$ 24.16	$ 28.00
$ 24.16	$ 28.00
$ 22.24	**$ 26.13**

Appendix 6 Supply data at CEDA (pilot 2)

During the second pilot the tomato supply weight per day was identified. There were three types of jitomate:

Table 26 Overview of supply data during second pilot in November 2022.

Volumen de entrada. Jitomate											Volumen de entrada Jitomate
No	Fecha	Cajas a Granel			Carton Saladet			Carton Bola			
		No. De cajas	Peso por caja (kg)	Subtotal (kg)	No. De cajas	Peso por caja (kg)	Subtotal (kg)	No. De cajas	Peso por caja (kg)	Subtotal (kg)	Total (kg)
1	7-11-2022	14,700.00	30.00	441,000.00	58,080.00	12.00	696,960.00	2,000.00	10.00	20,000.00	1,157,960.00
2	8-11-2022	20,800.00	30.00	624,000.00	50,235.00	12.00	602,820.00	3,250.00	10.00	32,500.00	1,259,320.00
3	9-11-2022	19,800.00	30.00	594,000.00	57,085.00	12.00	685,020.00	4,600.00	10.00	46,000.00	1,325,020.00
4	10-11-2022	19,500.00	30.00	585,000.00	42,590.00	12.00	511,080.00	3,800.00	10.00	38,000.00	1,134,080.00
5	11-11-2022	20,800.00	30.00	624,000.00	47,770.00	12.00	573,240.00	3,800.00	10.00	38,000.00	1,235,240.00
6	12-11-2022	18,800.00	30.00	564,000.00	50,330.00	12.00	603,960.00	2,780.00	10.00	27,800.00	1,195,760.00
7	13-11-2022	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
8	14-11-2022	7,700.00	30.00	231,000.00	27,540.00	12.00	330,480.00	3,200.00	10.00	32,000.00	593,480.00
9	15-11-2022	12,500.00	30.00	375,000.00	33,000.00	12.00	396,000.00	650.00	10.00	6,500.00	777,500.00
10	16-11-2022	12,700.00	30.00	381,000.00	32,570.00	12.00	390,840.00	2,900.00	10.00	29,000.00	800,840.00
11	17-11-2022	13,900.00	30.00	417,000.00	35,580.00	12.00	426,960.00	2,200.00	10.00	22,000.00	865,960.00
12	18-11-2022	14,000.00	30.00	420,000.00	40,030.00	12.00	480,360.00	7,700.00	10.00	77,000.00	977,360.00
13	19-11-2022	8,500.00	30.00	255,000.00	42,420.00	12.00	509,040.00	100.00	10.00	1,000.00	765,040.00
14	20-11-2022	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
15	21-11-2022	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
16	22-11-2022	14,400.00	30.00	432,000.00	39,105.00	12.00	469,260.00	1,150.00	10.00	11,500.00	912,760.00
17	23-11-2022	13,100.00	30.00	393,000.00	47,510.00	12.00	570,120.00	1,300.00	10.00	13,000.00	976,120.00
18	24-11-2022	14,900.00	30.00	447,000.00	48,765.00	12.00	585,180.00	5,400.00	10.00	54,000.00	1,086,180.00
19	25-11-2022	18,000.00	30.00	540,000.00	50,525.00	12.00	606,300.00	5,200.00	10.00	52,000.00	1,198,300.00
	kg			**7,323,000.00**			**8,437,620.00**			**500,300.00**	**16,260,920.00**
	Toneladas			**7,323.00**			**8,437.62**			**500.30**	**16,260.92**

Appendix 7 Template for container selection

	Fecha:	10-10-2022	Monday			
No.	Pasillo	Horario	Patio 1	Patio 2	Patio 3	Patio 4
1	I	9:00				
2	I	13:00				
3	I	17:00				
4	J	9:00				
5	J	13:00				
6	J	17:00				
7	K	9:00				
8	K	13:00				
9	K	17:00				
10	L	9:00				
11	L	13:00				
12	L	17:00				
13	M	9:00				
14	M	13:00				
15	M	17:00				
16	N	9:00				
17	N	13:00				
18	N	17:00				
19	O	9:00				
20	O	13:00				
21	O	17:00				
22	P	9:00				
23	P	13:00				
24	P	17:00				
25	Q	9:00				
26	Q	13:00				
27	Q	17:00				
28	R	9:00				
29	R	13:00				
30	R	17:00				
31	S	9:00				
32	S	13:00				
33	S	17:00				
34	T	9:00				
35	T	13:00				
36	T	17:00				
37	U	9:00				
38	U	13:00				
39	U	17:00				
40	V	9:00				
41	V	13:00				
42	V	17:00				
43	W	9:00				
44	W	13:00				
45	W	17:00				
46	X	9:00				
47	X	13:00				
48	X	17:00				
No.	Pasillo	Horario	Patio 1	Patio 2	Patio 3	Patio 4

Example of container selection process as applied by CEDA (case of tomato in pilot 2). This table is for one day, and the observations should be carried out for 7 consecutive days.

	Fecha:	10-10-2022	Monday			
No.	Pasillo	Horario	Patio 1	Patio 2	Patio 3	Patio 4
1	I	9:00	----	VFT	----	----
2	I	13:00	----	----	----	----
3	I	17:00	VFT	----	----	----
4	J	9:00	----	----	----	----
5	J	13:00	----	----	----	----
6	J	17:00	----	----	----	----
7	K	9:00	----	CO	----	----
8	K	13:00	----	CO	----	----
9	K	17:00	----	----	----	----
10	L	9:00	----	----	----	----
11	L	13:00	----	----	----	CO
12	L	17:00	----	----	----	CO
13	M	9:00	----	----	----	----
14	M	13:00	----	----	----	To
15	M	17:00	----	----	----	----
16	N	9:00	----	VFT	----	----
17	N	13:00	CO	----	----	----
18	N	17:00	----	----	----	----
19	O	9:00	----	----	----	----
20	O	13:00	----	----	----	----
21	O	17:00	----	----	----	----
22	P	9:00	----	----	----	----
23	P	13:00	FT	----	----	----
24	P	17:00	----	----	----	VFT
25	Q	9:00	To	----	FT	----
26	Q	13:00	LT	----	----	----
27	Q	17:00	LT	VFT	To	----
28	R	9:00	VFT	----	----	----
29	R	13:00	LT	----	----	----
30	R	17:00	LT	VFT	----	----
31	S	9:00	----	----	----	----
32	S	13:00	----	----	----	CO
33	S	17:00	----	----	----	----
34	T	9:00	----	----	----	----
35	T	13:00	----	VFT	CO	----
36	T	17:00	----	----	----	----
37	U	9:00	----	----	----	----
38	U	13:00	----	----	VFT	VFT
39	U	17:00	----	----	----	----
40	V	9:00	VFT	VFT	----	----
41	V	13:00	VFT	----	----	----
42	V	17:00	----	----	----	----
43	W	9:00	----	----	----	----
44	W	13:00	----	----	VFT	VFT
45	W	17:00	----	----	----	----
46	X	9:00	----	----	----	----
47	X	13:00	----	CO	----	----
48	X	17:00	----	----	----	NP
No.	Pasillo	Horario	Patio 1	Patio 2	Patio 3	Patio 4
	CO	Container out		8		
	VFT	very few tomato		15	I1, I2, N2, P4, Q2, R1, R2, T2, U3, U4, V1, V2,W3,W4	
	FT	Few tomato		2	P1, Q3	
	To	Tomato		3	M4, P1, Q3	
	LT	A lot tomato		4	Q1, R1	
	ST	Seems tomato	(picture not clear)		0	
	NP	No picture		1		
	----	No tomato		159		
		Total Images	192	192		
	Candidatos:	P1, Q3, M4, P1, Q1, R1				
	Candidatos que aparecen solo una ocasión:				Q3, M4, I3, J3, O4, U3, N4	
	Por lo tanto,	Q3, M4, I3, J3, O4, U3, N4		quedan descartados		
	Seleccionados:		P1, Q1, R1, R2			

Appendix 8 Link to the EFFICIENT Protocol and Cause tree and intervention tool

Link to the EFFICIENT Protocol https://www.wur.nl/en/research-results/research-institutes/food-biobased-research/show-fbr/take-the-target-measure-act-approach-to-reduce-food-waste-yes-but-be-pragmatic-about-it.htm

Link to Cause tree and intervention tool https://the-efficient-protocol.azurewebsites.net/

Appendix 9 Template for Scope definition

1. Scope phase

General

Starting point	Client wants to monitor, identify food loss and waste (FLW) hotspots, find causes and/or assess interventions.
Goal of this phase	To define the scope of the study.
Specified goal	1. Link/chain/network in scope and geographical area; 2. The level of detail in product and time; 3. The required accuracy and detail of the data used.
Source of information	Client
Method	Questionnaire
Output	The scope of the study.

Method Interviewing the client (optionally with multiple participants from the client's organization).

Questionnaire

0. General

Name Client	XX & CEDA
Name Organization client	Trader - Problem owner & CEDA

1. Goal *What is the goal of your EFFICIENT study?*

Answer: Decrease (economic) food loss and waste and calculate investment space for investment

2. Product *Briefly describe the food product of interest. Level of interest can be at three levels: product category - product -variety. Examples are: a) fruit in general as a category, b) cauliflower and lettuce, no specific varieties c) potato (Shangi and Dutch Robyn variety).*

Answer: White onions

3. Part of the supply chain/network/sector *Which SCLs should be included? Tick the boxes you include. Next, select 'generic' when a group of actors is analysed (include geographical region), and select 'specific' if specific actors are analyzed (include name and address).*

Answer:

	generic	Geographical region	specific	name and address	Remark
☑ Agricultural producer			x	5 farmers in XXX - XX Farmer 1 - Mario Farmer 2- Farmers that deliver to XX trader	Together 700 hectares. Deliver between september-december
☐ Collector					
☑ Trader			x	Trader 1: XX Trader 2: XY	
☐ Processor					
☑ Wholesaler			x	CEDA market	
☐ Retailer					
☐ Mobile vendor					
☐ Restaurant					
☑ Industry	x	For export			Main market, processed
☑ Other clients	x	Domestic			All other type of clients including hotel/restaurants, consumers,etc.
☐					

4. Indicator *How do you want to express the FLW? What unit per what time period?*

Examples
- a *tons/ha per year (e.g. Farmer)*
- b *50 kg bags as % of number of 50 kg bags as input per year (e.g. retailer)*
- c *value loss (sales price x price per unit) per season*
- ...

Multiple answers are possible

Answer:

Loss in kg/year
Value loss (sales price x price per unit) per year

5. Availability of data sources *Do you know of any available sources for FLW data? When available, provide details below.*

Example: Reports, recent studies with public results, national statistics, results from measurements, documents with expert estimates, websites.

Answer:

Source 1	-
Source 2	

6. Quality of data (see 5.) *How do you consider the quality of these data?*

	Latest data available (year)	Reliability	Level of detail
Source 1	-	-	-
Source 2			

7. Experts Do you have experts in mind who may help identifying the determination of the food flow?

Answer:

	Name	Function and organization	Contact
1	XX	Trader and problem owner	
2		CEDA	
3			

Appendix 10 Questionnaires for the definition of product and residual flows

English

CEDA Questions for Flow Phase 2: Definition of product and residual flows

The questions are aimed to identify the FLW hotspots and mitigation options, and at understanding the product flows, inputs, and residues from the supply chain. Global layout of the supply chain must be supplied by local actors/experts. For quantitative data we have the following preferences:

- preferably the data are actual (average) values given by an actor
- if that is not available, an expert may provide an average or expert guess
- final option is that WUR estimates the values (based on secondary data).

Information requirement

Agricultural producers

Name producer(s):
Date of interview:
Location:

<u>Production</u>

1. What is the size of the production field for this crop? How do you decide upon the size of the production area?
2. Do you produce based on contracts with buyers? Please explain.
3. What problems do occur during the production of the specific product?

<u>Harvest</u>

4. What harvest tool(s) do you use?
5. What is the expected yield per hectare?
6. How many production seasons are in one year? Calculate total yield per year.
7. What problems do occur when harvesting?
8. What % of the product do you estimate was left in the field 'unharvested'? (include unharvest product, deformed/infected produce, and damaged product due to harvesting)
    a. What are the causes that not all products were successfully harvested? (include unharvest product, deformed/infected produce, and damaged product due to harvesting)
    b. What is the destination of these 'unharvested' products?

<u>Post-harvest</u>

9. What post-harvest activities do you do e.g. transport, sorting, grading, curing, storage (how, how long, use of pesticides, losses..), packaging?
10. Where do you perform which activity?
11. What problems do you face during the post-harvest activities?
12. What % of the successfully harvested product do you estimate was sorted out/lost during the post-harvest activities?
    a. What are the causes of this?
    b. What is the destination of these out-sorted/lost products?
13. In case of processing: which fraction (percentage) is separated from the food product? What is the destination of that stream?
14. Do you apply refrigeration to the product? If yes, how long is the average refrigerated storage duration? Do you have an idea of electricity use per ton product?

15. Do you apply packaging? Specify material + kg packaging material per kg food product.

Transport

16. Are you responsible for the transport? Please specify
17. What is the actual transportation distance (km or mile) per load?
18. What problems do you face during transportation?

Sales and connection

19. What is your intended market actor to sell your produce to?
20. To what actor(s) do you sell the product?
21. How is the relationship between you and the buyers? Always sell to the same buyer?
22. How are transactions made?
23. How are prices determined? Is payment based on quality?
24. What are the total production costs per ton product?
25. What are the average selling prices per ton product?
26. What problems do you face during selling produce?
27. What % of the ready-to-sell products do you estimate was unsold?
    a. What are the causes of unsold product?
    b. What is the destination of these unsold products?

Other

28. Where do you think the biggest losses occur?
29. What are your main challenges?
30. What are in your opinion the best solutions to solve these problems?

Traders / agents / other intermediaries/ wholesalers

Name Trader(s):
Date of interview:
Location:

Sourcing and connection

1. From what type of actor(s) do your source your products? How do you decide how much you buy per farmer/supplier and region?
2. What is the total volume you purchase per year per region?
3. How is the relationship between you and the sellers? Always purchase from the same individual/group of actors?
4. How are transactions made?
5. How are prices determined? Is payment based on quality?
6. What is the average purchase price per ton product?
7. What problem do you face when sourcing products?

Handling/activities

8. What handling activities (storage, transport, buying, packaging, repacking…)do you?
9. Where do you perform which activity?
10. What problems do you face during the handling activities?
11. What are the handling costs? Please specify
12. In case sorting is performed, what % of the sourced products are sort-out?
    a. What are the causes of this?
    b. What is the destination of these out-sorted/lost products?
13. What facilities do you have?
14. In case of processing: which fraction (percentage) is separated from the food product? What is the destination of that stream?
15. Do you apply refrigeration to the product? If yes, how long is the average refrigerated storage duration?
16. Do you apply packaging? Specify material + kg packaging material per kg food product.

Transport

17. For what transport are you responsible? E.g. agricultural producers to own location, rural wholesale market to urban wholesale market, etc.
18. What is the actual transportation distance (km or mile) per load?
19. What problems do you face during transportation?

Sales and connection

20. What is your intended market actor to sell your produce to?
21. To what actor(s) do you sell the product?
22. How is the relationship between you and the buyers? Always sell to the same buyer?
23. How are transactions made?
24. How are prices determined? Is payment based on quality?
25. What are the average selling prices per ton product?
26. What % of the ready-to-sell products do you estimate was unsold?
    a. What are the causes of unsold product?
    b. What is the destination of these unsold products?

Other

27. Where do you think the biggest losses occur?
28. What are your main challenges?
29. What are in your opinion the best solutions to solve these problems?

Spanish translation of the questionnaire for the definition of product and residual flows (translation realized in collaboration with CEDA)

Preguntas para el Flujo de la fase 2 (WP2): Definición de producto y flujo residual

Las preguntas para el WP2 tienen como objetivo identificar los puntos conflictivos de la FLW y las opciones de mitigación, así como comprender los flujos de productos, insumos y residuos de la cadena de suministro. La disposición global de la cadena de suministro debe ser suministrada por actores/expertos locales. Para los datos cuantitativos, tenemos las siguientes preferencias en cuanto al suministro de datos

- Preferentemente los datos son valores actuales (promedio) dados por un actor
- si no se dispone de ellos, un experto puede proporcionar una media o una estimación expert
- la última opción es que WUR estime los valores (basándose en datos secundarios).

Requisitos de información

Productores agrícolas:

Nombre del productor o productores:
Fecha de la entrevista:
Ubicación:

Producción

1. ¿Cuál es el tamaño del campo de producción de este cultivo? ¿Cómo decide el tamaño de la superficie de producción?
2. ¿Produce en base a contratos con compradores? Por favor, explique.
3. ¿Qué problemas surgen durante la producción del producto específico?

Cosecha

4. ¿Qué herramientas de cosecha utiliza?
5. ¿Cuál es el rendimiento esperado por hectárea?
6. ¿Cuántas temporadas de producción hay en un año? Calcule el rendimiento total por año.
7. ¿Qué problemas se producen en la cosecha?
8. ¿Qué porcentaje del producto estima que se dejó en el campo "sin cosechar"? (incluya el producto no cosechado, el producto deformado/infectado y el producto dañado debido a la cosecha)
    a. ¿Cuáles son las causas de que no se hayan cosechado con éxito todos los productos? (incluya el producto no cosechado, el producto deformado/infectado y el producto dañado debido a la cosecha)
    b. ¿Cuál es el destino de estos productos "no cosechados"?

Post-cosecha

9. ¿Qué actividades postcosecha realiza, por ejemplo, el transporte, la selección, la clasificación, el curado, el almacenamiento (cómo, cuánto tiempo, uso de pesticidas, pérdidas...), el envasado?
10. ¿Dónde realiza cada actividad?
11. ¿Qué problemas tiene durante las actividades posteriores a la cosecha?
12. ¿Qué porcentaje del producto cosechado con éxito estima que se clasificó/perdió durante las actividades posteriores a la cosecha?
    a. ¿Cuáles son las causas?
    b. ¿Cuál es el destino de estos productos extraviados/perdidos?
13. En caso de procesamiento: ¿qué fracción (porcentaje) se separa del producto alimentario? ¿Cuál es el destino de esa corriente?
14. ¿Se aplica refrigeración al producto? En caso afirmativo, ¿cuál es la duración media del almacenamiento refrigerado?
15. ¿Utiliza envases? Especifique el material + kg de material de envasado por kg de producto alimentario.

Transporte
16. ¿Es usted responsable del transporte? Especifique
17. ¿Cuál es la distancia real de transporte (kilómetros o millas) por carga?
18. ¿Qué problemas tiene durante el transporte?

Venta y conexión
19. ¿Cuál es el actor del mercado al que quiere vender sus productos?
20. ¿A qué agente o agentes vende el producto?
21. ¿Cómo es la relación entre usted y los compradores? ¿Vende siempre al mismo comprador?
22. ¿Cómo se realizan las transacciones?
23. ¿Cómo se determinan los precios? ¿Se paga en función de la calidad?
24. ¿Cuáles son los costes totales de producción por tonelada de producto?
25. ¿Cuáles son los precios medios de venta por tonelada de producto?
26. ¿Qué problemas se plantean durante la venta del producto?
27. ¿Qué porcentaje de los productos listos para la venta estima que no se ha vendido ¿
    a. Cuáles son las causas de los productos no vendidos?
    b. ¿Cuál es el destino de estos productos no vendidos?

Otros
28. Dónde cree que se producen las mayores pérdidas?
29. ¿Cuáles son sus principales retos?
30. ¿Cuáles son, en su opinión, las mejores soluciones para resolver estos problemas?

Comerciantes / agentes / otros intermediarios / mayoristas
Nombre Comerciante(s):
Fecha de la entrevista:
Lugar:

Abastecimiento y conexión
1. ¿De qué tipo de actores se abastece? ¿Cómo decide la cantidad que compra por agricultor/proveedor y región?
2. ¿Cuál es el volumen total que compra al año por región?
3. ¿Cómo es la relación entre usted y los vendedores? ¿Compran siempre al mismo individuo/grupo de actores?
4. ¿Cómo se realizan las transacciones?
5. ¿Cómo se determinan los precios? ¿El pago se basa en la calidad?
6. ¿Cuál es el precio medio de compra por tonelada de producto?
7. ¿Qué problemas se plantean a la hora de adquirir los productos?

Manipulación/actividades
8. ¿Qué actividades de manipulación (almacenamiento, transporte, compra, envasado, reenvasado...) realiza?
9. ¿Dónde realiza cada actividad?
10. ¿A qué problemas se enfrenta durante las actividades de manipulación?
11. ¿Cuáles son los costes de manipulación? Por favor, especifique
12. En caso de que se lleve a cabo la clasificación, ¿qué porcentaje de los productos obtenidos se clasifica?
    a. ¿Cuáles son las causas de ello?
    b. ¿Cuál es el destino de estos productos fuera de clasificación/perdidos?
13. ¿De qué instalaciones disponen?
14. En caso de procesamiento: ¿qué fracción (porcentaje) se separa del producto alimentario? ¿Cuál es el destino de esa corriente?
15. ¿Aplica la refrigeración al producto? En caso afirmativo, ¿cuál es la duración media del almacenamiento refrigerado?
16. ¿Utiliza envases? Especifique el material + kg de material de envasado por kg de producto alimentario.

Transporte

17. ¿De qué transporte es responsable? Por ejemplo, de los productores agrícolas a su propia ubicación, del mercado mayorista rural al mercado mayorista urbano, etc.
18. ¿Cuál es la distancia real de transporte (kilómetros o millas) por carga?
19. ¿Qué problemas tiene durante el transporte?

Venta y conexión

20. ¿Cuál es su actor de mercado previsto para vender sus productos?
21. ¿A qué agente o agentes vende el producto?
22. ¿Cómo es la relación entre usted y los compradores? ¿Vende siempre al mismo comprador?
23. ¿Cómo se realizan las transacciones?
24. ¿Cómo se determinan los precios? ¿Se paga en función de la calidad?
25. ¿Cuáles son los precios medios de venta por tonelada de producto?
26. ¿Qué porcentaje de los productos listos para la venta estima que no se vendió?
    a. ¿Cuáles son las causas de los productos no vendidos?
    b. ¿Cuál es el destino de estos productos no vendidos?

Otros

27. Dónde cree que se producen las mayores pérdidas?
28. ¿Cuáles son sus principales retos?
29. ¿Cuáles son, en su opinión, las mejores soluciones para resolver estos problemas?

Appendix 11 Analysis of the questionnaires

Example analyse onion questionnaires

	Producer A	**Trader A**	**Trader B**
1. Total hectares	1	-	
10. Yield/ha	<50 tons/ha	40-60 tons	
11. Seasons/year	2	-	
13. % onions unharvested/deformed/damaged due to harvesting	Ten percent due to shrinkage and ripening or out-of-specification problems	2%-5% of planting due to weather	
13b. Destination of these products	Sub-harvest/sub products or local markets	Donation or animal feed	
14. Post-harvest activities	Transport, Handling, packaging. Activities in one day. Prepare for transport of sold product?	Transportation, sorting, grading. All in one day Prepare for transport of sold product	
18. % processing losses	10%	10%	
18. Destination	Shrinkage or local market	Donation	
24. Vehicle	-	Trucks loaded with 25-27 tons Cage loaded with 40 tons Torton loaded with 20 tons	
26. Sell to	Industry, self-service chains	Industry, restaurants and (super)market	
31. Production costs	-	5 pesos/kg, but depending on the yield per hectare	
31. Selling prices	-	Depending on supply/demand	
34. % loss due to no sell	-	We try to sell 100%	
34B. Destination	-	When onions remain, go to donation	
	Trader B	**Trader A**	
1. Purchase from	Farmers from different regions	Farmers in different regions depending on time of the year	
2. Total volume purchase per year/region	Variable. 2x19 tons per day = 38 tons/day, 38*365 = 13,870 (for all regions together	2,000-4,000 tons, depending on the region	
6. Purchase price	Variable	Prices vary due to several factors	
8. Activities	Own production field; Transportation, Selection/sorting, and cleaning in the CEDA warehouse, repacking, Storage in warehouse up to 2 weeks if needed Transportation only from Morelos own	Storage and repacking in our warehouse. Transport from producers to own location or urban wholesale market. From field to CEDA market and industry is our responsibility	

	production field, other parts: The producer offers delivery in warehouse		
12. Sorting losses %	Good quality: supermarket Normal quality: Lower prices in public markets, restaurants, and other food markets	0% No sorting losses, only for size variations to determine classification and market	
23. Market selling to	Supermarkets (preference), markets, other warehouses, and other supply centres	Industry and markets	
27. Selling prices	Fluctuate	Fluctuate, difficult to estimate	
28. % unsold	Sales can be estimated	0%, try to sell everything	
28B. Destination	Onion powder (cleaning product) and donations to food banks (tax deductible)	Donations	

Appendix 12 Food and residual flow

2. Food flow phase: a) Make your food flow diagram

You can also make the food flow diagram in another program, like Visio, Paint or PowerPoint, and copy-paste the result.

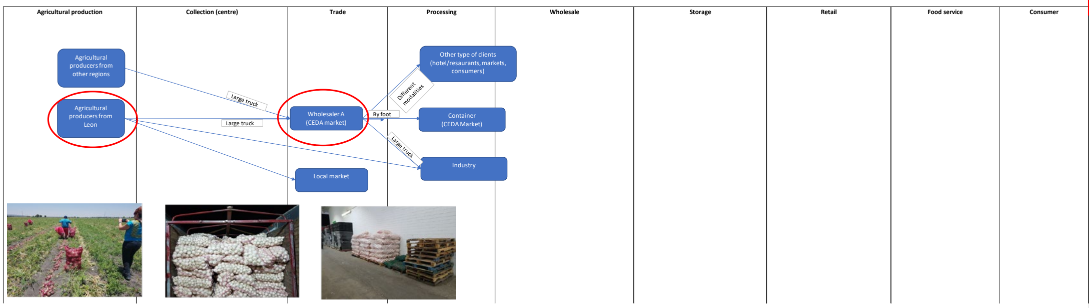
Building blocks
Copy-paste the building blocks if you need more

Actors

[Actor]
[Actor]
[Actor]

Food flow

Mode of transportation
By foot
Car
Van
Pick-up
Small truck
Large truck
[...]



Back

2. Food flow phase: b) Food flow diagram including information tables

You can also make the food flow diagram including the information tables in another program, like Visio, Paint or PowerPoint, and copy-paste the result.

Building blocks
Copy-paste the building blocks if you need more

To do:
1. Make the same food flow diagram as you made in A), but swop the 'blue actor bars' with the tables below.
2. Fill in the tables

Agricultural producers other regions

Yield or input volume/ selected time period (in tonnes) (1)	Total unknown	Total sales volume (in tonnes) (5)	... (tonnes)
Activities (2)	Tonnes deviated (3a)	% deviated (3b)	**destination (4)**
Unknown	Unknown	Unknown	Unknown
Lead time (6)		...	hours

Wholesaler A

Yield or input volume/ selected time period (in tonnes) (1)	19,710	Total sales volume (in tonnes) (5)	16,734
Activities (2)	Tonnes deviated (3a)	% deviated (3b)	**destination (4)**
Transport from production to CEDA market	0	0%	-
Sorting & re-packing	2,345	11.9%	Sell to other clients for cheaper price
	512	2.6%	Container
Peeling/cleaning	2,464	12.5%	Container (only the peel)
Storage	0	0%	-
Lead time (6)		48	hours

900 tons

Other clients

Yield or input volume/ selected time period (in tonnes) (1)	Total unknown	Total sales volume (in tonnes) (5)	... (tonnes)
Activities (2)	Tonnes deviated (3a)	% deviated (3b)	**destination (4)**
Buy at CEDA market	Unknown	Unknown	Unknwon
Lead time (6)		...	hours

54

6,502 tons

Industry

Yield or input volume/ selected time period (in tonnes) (1)	Total unknown	Total sales volume (in tonnes) (5)	... (tonnes)
Activities (2)	Tonnes deviated (3a)	% deviated (3b)	**destination (4)**
Pick up at CEDA Market	Unknown	Unknown	Unknown
Processing	Unknown	Unknown	Unknown
Lead time (6)		...	hours

7,560 tons

Agricultural producers from Leon

Yield or input volume/ ha (in tonnes) (1)	50	Total sales volume (in tonnes) (5)	46
Activities (2)	Tonnes deviated (3a)	% deviated (3b)	**destination (4)**
Production	Unknown	Unknown	Unknown
Harvest	2	4%	Animal feed, leave on land or donation
internal transport	0	0%	-
Sorting & packing	2.5	5%	Leave on land or donation
Sales & prepare for transport	-	0%	Donation
Lead time (6)		Sold direct after harvest	hours

Local market

Yield or input volume/ selected time period (in tonnes) (1)	Total unknown	Total sales volume (in tonnes) (5)	... (tonnes)
Activities (2)	Tonnes deviated (3a)	% deviated (3b)	**destination (4)**
Unknown	Unknown	Unknown	Unknown
Lead time (6)		...	hours

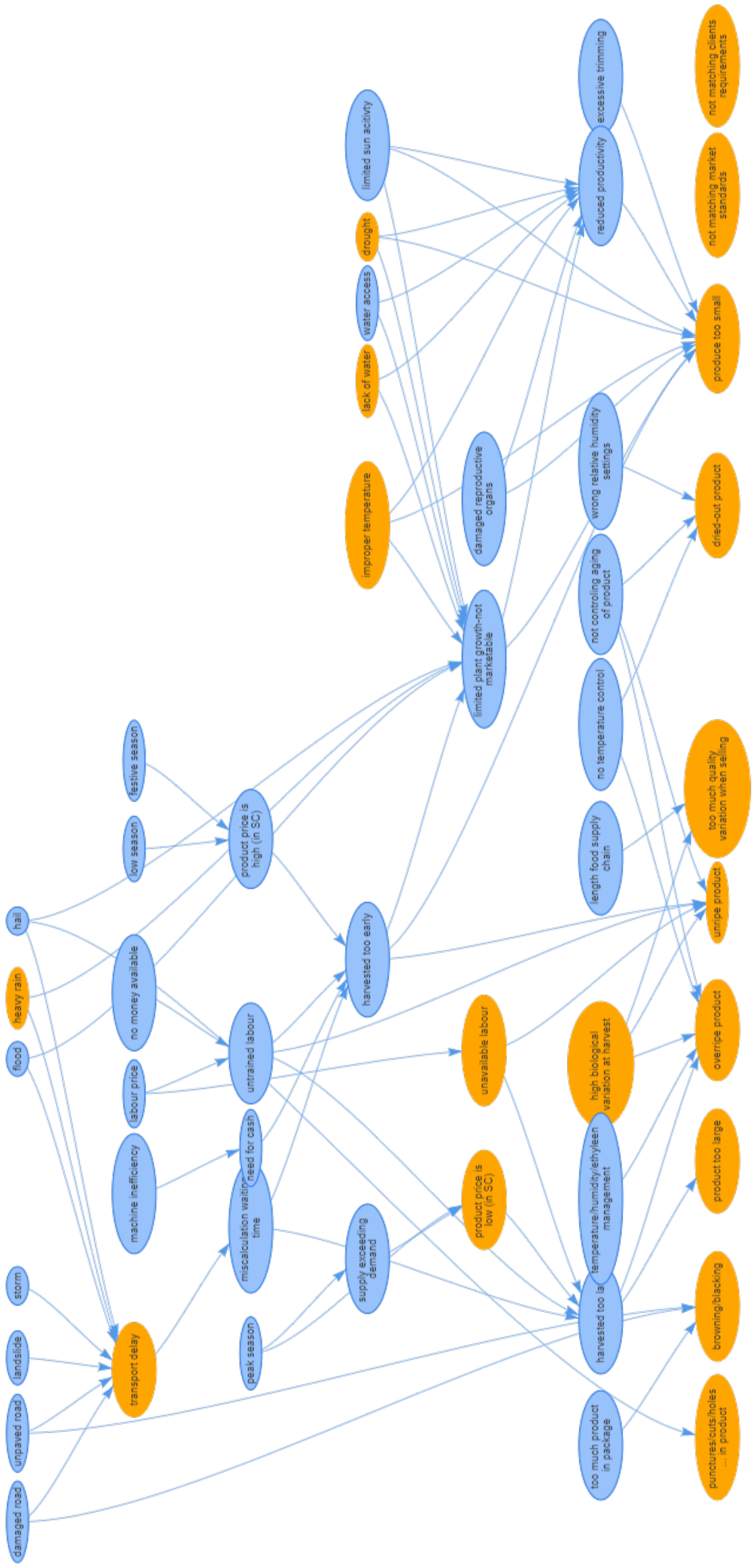
Appendix 13 Measurement Protocol for the CEDA Wholesalers

Onion measurement protocol CEDA market sellers					
1. Instruction: Take 20 sacks out of the truck and select the good and bad onions, weigh them, weigh the waste and sell at a lower price. Please also tell us the purchase and sales price value is. 1. Instrucion : Sacar 20 sacos del camión y seleccionar las cebollas buenas y las malas, pesarlas, pesar los desperdicios y las ventas a menor precio. Por favor, también díganos el valor del precio de compra y venta.					
2. Data entry: Measurements					
Product	Date	Weight of 20 bags kg	Onion in good condition kg	Onion in poor condition kg	Waste for container kg
PRODUCTO	Fecha	Peso de 20 sacos kg	Cebolla en buen estado kg	Cebolla en mal estado kg	Desperdicio para contenedor kg
Purchase price					
Selling price 1st market					
Selling price 2nd market					
Price Wastebin					

3. Data analysis							
Total	Sale 1st market (no waste)	1st %	Sale 2nd market (economic loss)	2nd %	Sale waste (food waste)	% waste to wastebin	Confirmation
Total	Venta 1ra		Venta 2da		Desperdicio	% desperdicio	Confirmación
=C6	=D6	=B20/A20	=E6	=D20/A20	=F6	=F20/A20	**=B20+D20+F20**
=C7	=D7	=B21/A21	=E7	=D21/A21	=F7	=F21/A21	**=B21+D21+F21**
=C8	=D8	=B22/A22	=E8	=D22/A22	=F8	=F22/A22	**=B22+D22+F22**
	Total division	**=AVERAGE(C20:C22)**		**=AVERAGE(E20:E22)**		**=AVERAGE(G20:G22)**	

Appendix 14 Cause tree to identify FLW root causes

Example of the onion cause tree tool to identify the root causes of FLW. Orange = causes from interviews.



To explore the potential of nature to improve the quality of life

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The mission of Wageningen University & Research is “To explore the potential of nature to improve the quality of life”. Under the banner Wageningen University & Research, Wageningen University and the specialised research institutes of the Wageningen Research Foundation have joined forces in contributing to finding solutions to important questions in the domain of healthy food and living environment. With its roughly 30 branches, 7,200 employees (6,400 fte) and 13,200 students and over 150,000 participants to WUR’s Life Long Learning, Wageningen University & Research is one of the leading organisations in its domain. The unique Wageningen approach lies in its integrated approach to issues and the collaboration between different disciplines.