Impact assessment for the project
LIFE FOODPRINT

Deliverable 2: Final Report

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For the compilation of the report, a great amount of data was supplied by the LIFE FOODPRINT project. The data are the property of the LIFE FOODPRINT project and the members of the consortium that developed/extracted them. Additional data and LCA modelling were developed by VL Sustainability Metrics LTD.

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Summary

Food waste is the discarding or wastage of edible food that is still fit for human consumption. Globally, around a third of all food produced for human consumption (1.3bn tons) is lost or wasted. Cyprus ranks third amongst EU member states in annual food waste. LIFE FOODPRINT project aimed to raise awareness, inform, train, and strengthen the collaboration among the stakeholders related to this environmental issue. The aim of this report is to provide the environmental impact of the project and its main topics are food waste production, environmental impacts, food waste prevention and environmental benefits, and awareness to entities and citizens. The key findings of this report are the following:

- Awareness raising on the issue of food waste is important for the Cypriot society and could lead to an important decrease in food waste. This has environmental, economic, and social benefits.
- Targeted campaigns for food purchase should stress the issues of overconsumption that lead to food waste.
- According to project data, 2.469 kg of food waste per household per week are produced and sent to a landfill. The estimated annual residential food waste in Cyprus is 47,746.24 tons.
- The food loss per person and year was estimated at 1000 euros (LIFE foodprint calculator).
- An estimated food waste amount of 110,504 tons/year is attributed to hospitality and restaurant activity.
- Emissions due to food waste in landfills are estimated at 119,786,064 kg CO_2eq/year.
- If food waste is used for biogas production, there is a benefit equal to 131,555,001.14 kg CO_2eq per year (1.73% of annual national GHG emissions), mainly due to less waste to landfills, renewable energy production and replacing heavy fuel oil use for electricity production. Renewable electricity generation from food waste could be 13,791,828.59 kWh per year.
- The total number of individuals that the project reached by various means, were 804,445.
- The adoption of a zero-waste waste attitude from 100,000 citizens could lead to saving 17,237 tons of food waste per year.

Περίληψη

Ο όρος απόβλητα τροφίμων χρησιμοποιείται για να περιγράψει ποσότητες τροφίμων που καταλήγουν ως στερεά απόβλητα. Παγκοσμίως, 1/3 της παραγωγής τροφίμων σπαταλιέται και η Κύπρος είναι τρίτη στην ΕΕ στις ποσότητες τροφίμων που καταλήγουν στα απόβλητα. Το έργο LIFE FOODPRINT είχε ως στόχο να ενημερώσει, ευαισθητοποιήσει και ενισχύσει τη συνεργασία μεταξύ των ενδιαφερόμενων μερών για το ζήτημα αυτό. Ο στόχος της παρούσας έκθεσης είναι να παρουσιάσει τις περιβαλλοντικές επιδράσεις του έργου, με έμφαση στην παραγωγή αποβλήτων, τις επιπτώσεις, την αποτροπή και τα περιβαλλοντικά οφέλη, αλλά και το βαθμό της ευαισθητοποίησης φορέων και πολιτών. Τα κύρια αποτελέσματα του έργου συνοψίζονται στα παρακάτω:

- Η ευαισθητοποίηση είναι καίριας σημασίας. Οδηγεί σε μείωση των αποβλήτων και σε περιβαλλοντικά, οικονομικά και κοινωνικά οφέλη.
- Οι μελλοντικές εκστρατείες, οφείλουν να εστιάσουν στο θέμα της υπερκατανάλωσης.
- Σύμφωνα με τα στοιχεία του έργου, 2.469 kg αποβλήτων τροφίμων παράγονται κάθε εβδομάδα ανά νοικοκυριό, που οδηγούν σε ετήσια ποσότητα ίση με 47,746.24 τόνους.
- Το οικονομικό κόστος των αποβλήτων τροφίμων ανά κάτοικο και έτος (LIFE foodprint calculator) εκτιμήθηκε στα 1000 ευρώ.
- Οι εμπορικές δραστηριότητες (εστίαση και εστιατόρια) συμβάλλουν στην παραγωγή ποσότητας αποβλήτων τροφίμων, ίσης με 110,504 τόνους ετησίως.
- Οι εκπομπές από την διάθεση αποβλήτων τροφίμων σε Χώρους Υγειονομικής Ταφής Υπολειμμάτων (ΧΥΤΥ) εκτιμώνται σε 119,786,064 kg CO2eq/έτος.
- Εφόσον οι ποσότητες αποβλήτων τροφίμων διατίθενται σε μονάδες παραγωγής βιοαερίου, μπορεί να υπάρχει μείωση των εκπομπών της τάξης των 131,555,001.14 kg CO2eq/έτος. Η ενέργεια που μπορεί να παραχθεί υπολογίζεται σε 13,791,828.59 kWh/έτος.
- Το έργο συνέβαλε στην ευαισθητοποίηση 804,445 πολιτών στα θέματα αυτά.
- Η υιοθέτηση πρακτικών αποφυγής παραγωγής αποβλήτων τροφίμων (zero-waste attitude) από 100,000 πολίτες θα σήμαινε μείωση των παραγόμενων αποβλήτων κατά 17,237 τόνους το έτος.

1. Introduction

1.1. Food waste

Food waste is the discarding or wastage of edible food that is still fit for human consumption. It can occur at any stage of the food supply chain, from production to consumption. Food waste is a significant issue globally, with an estimated one-third of all food produced for human consumption being wasted or lost each year (Caldeira et al., 2019). This is a major problem as food waste has significant economic, environmental, and social impacts (Morone et al., 2019).

Economically, food waste represents a significant loss of resources, including the cost of production, transportation, and storage. It also contributes to higher food prices, as the wasted food is effectively a lost investment (Lopez Barrera and Hertel, 2021).

From an environmental perspective, food waste contributes to greenhouse gas emissions, as the decomposition of wasted food releases methane, a potent greenhouse gas, into the atmosphere (Munesue et al., 2015; Bernstad Saraiva Schott et al., 2016). Additionally, the resources used to produce the wasted food, such as water, energy, and land, are also wasted.

Socially, food waste contributes to food insecurity and hunger, as resources that could have been used to produce food for those in need are instead wasted.

To address the issue of food waste, it is important to reduce waste at all stages of the food supply chain (Kim et al., 2019). This includes better food planning and management at the household level, more efficient production and distribution systems, and greater awareness and education about the importance of reducing food waste.

1.2. Landfills

A landfill is a designated area where waste materials are disposed of and buried in the ground. Landfills are commonly used as a method of waste management to handle and control the vast amount of waste generated by human activities (Sauve and Van Acker, 2020).

Below are some key points about landfills:

Waste Disposal: Landfills are designed to handle various types of waste, including household garbage, industrial waste, construction debris, and other non-hazardous materials. Hazardous waste is typically disposed of in specialized facilities to minimize environmental risks.

Liner System: Landfills are constructed with a liner system to prevent the leakage of contaminants into the soil and groundwater. The liner usually consists of a layer of clay or synthetic material, followed by a layer of plastic or other impermeable material. This helps to protect the surrounding environment from pollution.

Waste Compaction: As waste is deposited in a landfill, it is compacted and spread out in layers. Compaction reduces the volume of the waste and creates more space for additional waste over time. The compacted waste is typically covered with soil or other materials to control odor, reduce vermin infestation, and promote decomposition.

Methane Gas Generation: Landfills are anaerobic environments, meaning that oxygen is limited. As organic waste decomposes in a landfill, it produces methane gas, which is a potent greenhouse gas contributing to climate change. To mitigate this, modern landfills often include gas collection systems to capture methane and utilize it as an energy source.

Environmental Concerns: Landfills can pose several environmental challenges. Improper waste management practices, such as inadequate liner systems or poor maintenance, can lead to groundwater contamination, soil pollution, and the release of harmful gases (Sauve and Van Acker, 2020). Landfills also occupy large areas of land, which can impact natural habitats and contribute to urban sprawl (Langa et al., 2021).

Waste Reduction Strategies: While landfills play a role in waste management, efforts are being made to reduce waste generation and promote recycling and composting. These strategies aim to minimize the amount of waste sent to landfills and promote a more sustainable approach to waste management (Johnston and Baker, 2020).

It's worth noting that waste management practices may vary between countries and regions, and there are ongoing efforts to develop more environmentally friendly alternatives to traditional landfill disposal, such as waste-to-energy facilities and increased recycling initiatives.

1.3. Biogas production

Biogas production is the process of generating gas, primarily methane (CH_4), through the anaerobic digestion of organic materials. It is considered a renewable energy source and a form of waste-to-energy conversion (Moya et al., 2017). Biogas can be used as a fuel for heating, electricity generation, and even as a vehicle fuel.

Below, key terms on biogas production are provided:
Anaerobic Digestion: Biogas production involves the decomposition of organic materials in the absence of oxygen, a process known as anaerobic digestion. Organic materials such as agricultural residues, food waste, animal manure, sewage sludge, and energy crops like corn and sugarcane are commonly used as feedstock.
Biogas Composition: The primary component of biogas is methane, typically ranging from 50% to 70%. The remaining composition includes carbon dioxide (CO_2), small amounts of other gases, and traces of impurities. Biogas may also contain hydrogen sulfide (H_2S), which needs to be removed before utilization due to its corrosive nature (Liu et al., 2020).
Biogas Utilization: Biogas can be used in various ways. It can be burned directly for heat generation or used in combined heat and power (CHP) systems to produce both heat and electricity (Modi et al., 2017). Biogas can also be upgraded to biomethane by removing impurities, resulting in a gas quality like natural gas. Biomethane can be injected into the natural gas grid or used as a transportation fuel.

Environmental Benefits: Biogas production offers several environmental advantages. It provides a renewable energy source that reduces reliance on fossil fuels. Additionally, the anaerobic digestion process helps divert organic waste from landfills, reducing methane emissions. Biogas facilities can also contribute to nutrient recycling by using animal manure or sewage sludge, reducing the environmental impact of these waste streams.

Digestate: Anaerobic digestion produces a byproduct called digestate, which is a nutrient-rich material resembling compost. Digestate can be used as a fertilizer, improving soil quality and nutrient cycling (Baştabak and Koçar, 2020).

Biogas Production Systems: Biogas can be produced through various systems, such as continuously stirred tank reactors (CSTR), plug-flow digesters, and covered lagoons. The choice of system depends on factors such as the feedstock, scale of operation, and desired biogas output.

Challenges and Considerations: Biogas production requires careful management and monitoring of the anaerobic digestion process. Factors such as temperature, pH, and feedstock composition need to be optimized for efficient biogas generation (Srivastava, 2020). Feedstock availability and logistics, potential odor issues, and the economic viability of biogas projects are also important considerations.

Biogas production plays a significant role in the circular economy and sustainable waste management by converting organic waste into valuable energy. It provides a renewable and environmentally friendly alternative to traditional fossil fuels, contributing to the reduction of greenhouse gas emissions and promoting a more sustainable energy future.

1.4. Biogas from animal waste

Biogas production from animal waste, such as livestock manure, is a common and valuable application of biogas technology. Animal waste contains organic matter that can be digested by bacteria in an anaerobic environment, resulting in the production of biogas. Below, basic characteristics of biogas production from animal waste are provided.

Feedstock: Livestock manure, including cow dung, pig manure, poultry litter, and other animal waste, is commonly used as the primary feedstock for biogas production. These wastes are rich in organic matter and nutrients, making them suitable for anaerobic digestion (Chowdhury et al., 2020).

Anaerobic Digestion Process: The anaerobic digestion process involves the decomposition of organic matter by bacteria in the absence of oxygen. Animal waste is collected and fed into an anaerobic digester, which is a sealed container or system. The digester provides an optimal environment for the bacteria to break down organic matter and produce biogas.

Biogas Composition: Biogas produced from animal waste typically consists of methane (50-70%), carbon dioxide, and small amounts of other gases. The methane content makes it a valuable energy source.

Benefits of Biogas Production from Animal Waste

Energy Generation: Biogas can be used as a renewable energy source for heating, electricity generation, or even as a vehicle fuel. It reduces dependence on fossil fuels and contributes to greenhouse gas mitigation.

Waste Management: Biogas production provides an environmentally friendly way to manage and treat animal waste. It helps reduce odors, pathogens, and nutrient runoff, minimizing the impact on soil and water quality (Hjorth et al., 2009).

Nutrient Recycling: The anaerobic digestion process generates a nutrient-rich byproduct called digestate. This digestate can be used as an organic fertilizer, returning valuable nutrients to the soil and closing the nutrient cycle.

Digester Systems: Various types of digester systems can be used for biogas production from animal waste, including covered lagoons, plug-flow digesters, and continuous stirred tank reactors. The choice of system depends on factors such as the scale of operation, available resources, and specific requirements.

Considerations and Challenges

Feedstock Characteristics: The composition of animal waste, such as its moisture content, nutrient content, and bedding material, can influence the performance of the anaerobic digestion process.

System Design and Operation: Proper design and operation of the digester system are crucial for efficient biogas production. Factors such as temperature, pH, retention time, and mixing should be carefully managed.
Sustainability and Economics: The economic viability of biogas production from animal waste depends on factors such as the cost of the digester system, availability and cost of feedstock, and potential revenue from energy sales or other incentives.

Biogas production from animal waste contributes to sustainable agriculture, reduces greenhouse gas emissions, and helps to create a more circular and environmentally friendly approach to animal farming.

1.5. Food waste to biogas

The conversion of food waste to biogas through anaerobic digestion is a promising waste-to-energy solution that addresses both waste management and renewable energy needs (Pham et al., 2015). It contributes to sustainable resource utilization and supports the transition to a more circular and environmentally friendly food system.

Food waste, including leftover food, food scraps, spoiled or expired food, and food processing waste, can serve as a valuable feedstock for biogas production. This waste can come from households, restaurants, grocery stores, food manufacturers, and other sources in the food supply chain. Converting food waste into biogas offers multiple environmental benefits. It reduces the amount of organic waste sent to landfills, thereby minimizing methane emissions, which is a potent greenhouse gas. Biogas production also helps to recover energy from waste and reduce reliance on fossil fuels.

Successful conversion of food waste to biogas requires careful management and consideration of various factors. These include waste collection and sorting systems, feedstock characteristics, digester design and operation, and ensuring a consistent and reliable supply of food waste (Uçkun Kiran et al., 2014).

1.6. Food waste prevention

Food waste prevention involves the collaboration and participation of various stakeholders across the food supply chain (Göbel et al., 2015; Aschemann-Witzel et al., 2017; Thapa Karki et al., 2021):

Producers and Suppliers: Farmers, growers, and food manufacturers play a crucial role in minimizing food waste at the production and supply level. They can implement efficient farming practices, such as optimizing harvest times, improving storage, and packaging techniques, and reducing losses during processing and distribution.

Retailers: Grocery stores, supermarkets, and other retail outlets have a significant impact on food waste prevention. They can implement strategies like accurate forecasting, proper inventory management, and product rotation to minimize food waste on their shelves. Retailers can also educate consumers about reducing food waste through clear labeling, portion control, and responsible purchasing.

Food Service Industry: Restaurants, cafeterias, hotels, and catering services are major contributors to food waste. They can take steps to prevent waste by implementing portion control measures, improving kitchen efficiency, managing leftovers, and donating excess food to charities or food banks.

Consumers: Individuals and households have a crucial role to play in reducing food waste. Consumers can practice responsible shopping, proper food storage, meal planning, and creative use of leftovers. Education and awareness campaigns can help raise consumer consciousness about the environmental and social impacts of food waste and encourage behavior change.

Food Banks and Charities: Food banks and charitable organizations play a vital role in rescuing surplus food and redistributing it to those in need. They can work closely with food producers, retailers, and the food service industry to collect and distribute excess food that would otherwise go to waste.

Government and Regulatory Bodies: Governments at local, regional, and national levels can support food waste prevention through legislation, regulations, and policy frameworks. They can provide incentives and financial support to businesses and organizations implementing food waste reduction strategies. Governments can also invest in public education campaigns, research, and infrastructure to address food waste challenges.

Non-Governmental Organizations (NGOs) and Advocacy Groups: NGOs and advocacy groups work to raise awareness about food waste and promote sustainable practices. They often collaborate with stakeholders, conduct research, and advocate for policy changes to tackle food waste issues.

Waste Management and Recycling Companies: Waste management companies play a role in managing and processing food waste that cannot be prevented. They can implement effective composting or anaerobic digestion systems to recover energy from food waste and reduce its environmental impact.

Collaboration and cooperation among these stakeholders are crucial to creating a comprehensive and effective approach to food waste prevention. By working together, they can address various stages of the food supply chain and make significant progress towards reducing food waste, conserving resources, and creating a more sustainable food system.

1.7. LIFE FOODPRINT project

In recent years, food waste has been one of the main topics of concern both on an EU and national level, resulting in negative effects on the environment, national economies, and EU citizens. Annual waste generation from all economic activities in the EU amounts to 2.5 billion tons, or 5 tons per capita a year, and each citizen produces on average nearly half a ton of municipal waste. The decoupling of waste generation from economic growth will require considerable effort across the whole value chain and in every home.

Globally, around a third of all food produced for human consumption (1.3bn tons) is lost or wasted (Pellegrini et al., 2019). Around 90 million tons/year of food waste on EU level. In the EU, about 173 kg/person of food waste are generated annually with related costs estimated at 14bn euros (Philippidis et al., 2019).

Recent studies have revealed that per capita, Cyprus ranks third amongst EU member states in annual food waste with 327kg/person after Netherlands

(541kg/person) and Belgium (345 kg/person) (European Council, 2022). Food waste in Cyprus is mainly driven by consumers routinely buying more food than needed. Another deficiency of the island is the lack of infrastructure for the separate collection and management of organic waste. Solid waste management contributes around 14% of the Cyprus greenhouse gas emissions (LIFE FOODPRINT, 2021).

According to this background information, the objectives of LIFE FOODPRINT project were:

Raise awareness on the scale of the food waste problem in the hospitality and food industries in Cyprus as well as among consumers.

Inform on sustainable solutions and practices to possibly prevent and reduce food waste through their application.

Train professionals and/or students of the food and hospitality industry to adopt more sustainable practices for food waste reduction and prevention.

Strengthen the collaboration between actors of the food supply chain and social actors for using supplementary food for "social food donation" initiatives.

Support the government and local authorities (policy makers) to create enabling policy environments that stimulate food waste prevention and reduction.

One key objective of the project was to directly involve stakeholders from the food and hospitality industries of Cyprus as well as social actors such as local authorities and NGOs in creating a "Collaboration Network" for "social food donation". This was achieved by a series of stakeholder meetings which took place throughout Cyprus. In total 24 meetings were held with 48 participants from the Food and Hospitality sector (donors) and NGO's (receivers).

The project implemented several consultations among stakeholders followed by training to professionals and students of the food and hospitality sectors. Participants in the consultations and training applied what they have learnt to their businesses and future employment. Fifteen consultations were conducted with the F&H sectors and six consultations with local authorities and NGO's representing all five districts of Cyprus. 102 professionals from the F&H sector were trained throughout the duration of the project, as were 205 students coming from public vocational schools (tertiary and technical secondary education) specializing in the fields of hotel professions, bakery, culinary arts, and catering.

In this project, awareness was raised through the implementation of communication activities and the use of communication tools foreseen mainly addressing consumers and the public. This was achieved by all the media and public awareness activities and tools as was the Foodprint Calculator which aimed to sensitize the general public in matters related directly to food waste.

Moreover, the project contributed to the EU effort to meet the Sustainable Development Goals (SDG) adopted in September 2015 by the United Nations General Assembly, which targets to halve per capita food waste at retail and consumer level and reduce food losses along the food production and supply chains by 2030.

On a national level, the project supported the process of achieving the national targets set regarding the Circular Economy aiming for a 10% reduction of the total municipal waste going to landfills by 2035.

1.8. Aims and objectives of this report

The aim of the current report is to provide the environmental impact assessment of the LIFE FOODPRINT project. The main sections (topics) of the Impact Assessment Report are:

- Food waste production,
- Food waste environmental impacts (LCA and Foodprint calculator)
- Food waste prevention and environmental benefits,
- Awareness of entities and citizens.

All the estimations of the Impact Assessment could be compared to the project KPIs to assess the efficiency of the project activities.

2. Methods

2.1 Food waste - data collection overview

LIFEFOODPRINT collected data on food waste produced in households, after using questionnaires focusing on household baskets (receipts from food purchase) in 2021, 2022 and 2023. In addition, a behavioral study was conducted involving 554, 551 and 510 consumers in 2020, 2022 and 2023 respectively. Moreover, data from the LIFEFOODPRINT CALCULATOR were collected from the users that access the tool. This data was used, among others, to estimate the food waste quantities and track possible behavioral change, due to the project actions as the participants belong to the project pool of citizens and stakeholders. Regarding waste from the commercial sector, similar research took place in 194 SME companies. The amounts of food waste (including cooking oil) were estimated for 3 years (2020-2022) for these companies. All the data was used for assessing the environmental footprint of food waste and alternative treatment options (e.g., landfill, biogas production, renewable energy production). Although there is additional data for food waste production in Cyprus (e.g., Frederick University and Dept of Environment), the calculation of environmental impact indicators in this report are based on data collected from the project (e.g., citizens and commercial sectors). Moreover, there were additional surveys with companies from the restaurant and hospitality sectors that took place during the period of the project. These data were not incorporated in the environmental impact estimations that are performed in this report. They are part of other deliverables of the project.

2.2. Food purchase in Cypriot households

Data for food purchase was collected after a survey that involved 64 households. The data collection was used as a proxy for determining the composition of food purchase in Cyprus and the amount of food waste per household, per week, as a specific question was present on the amount of food waste per household per week. Accordingly, receipts from food purchase were collected and a questionnaire (see Annex I) in Greek was distributed. All data collection was anonymous, and the participants were identified by a code-name. For each of the households, there was a responsible person assigned from the LIFE FOODPRINT partnership. The survey was conducted from January-March 2021 and with that, the first batch of the data was obtained. This functions as a baseline condition, as the participants also received information from the project, during its implementation. A second survey took place during February-May 2022 (middle of the project) and the same data were obtained. In this sense, the impact of the project to change consumer behavior, towards food use and waste production was assessed, as all participants were in the pool of citizens receiving information regarding LIFE FOODPRINT.

The following food categories were involved in this research:

- Vegetables
- Fruit
- Pasta
- Baked Goods
- Meat
- Milk Products
- Sweets/Desserts
- Fish
- Ready Food
- Dry Food
- Other Food

The data collected from a third survey (in 2023) were not used for food waste generation calculations in this report, as they were obtained close to the end of the project. However, they are close to the values obtained in the 2021 and 2022 surveys and the team considers that they do not change the results of this impact assessment report. These data are included in other deliverables, regarding citizens behavior towards food waste generation.

2.2.1. Baseline survey

Accordingly, in 41 households 586 receipts coming from food purchases were gathered. Additionally, questionnaires (n=33) were obtained, regarding the use of the food and food waste.

2.2.2. Midterm survey

A total of 297 receipts were gathered from a total of 23 Households. From these, 19 answers to the questionnaires were obtained. The people who submitted receipts were anonymous and only identified by a code-name and the responsible person assigned to them from the partner team.

2.3. Food utilization and waste production by consumers

The survey involved 554, 551 and 510 consumers in 2020, 2022 and 2023 respectively. The questions and data collection involved the following:

- Treatment of food leftovers.
- Frequency wasting specific food categories.
- Main reasons that food quality is deteriorated (and results in waste).
- Food quantity that is wasted.
- Practices followed at the individual and household level for reducing food waste.
- Reasons for purchasing more food than what is needed.
- Emotions after generating food waste.
- Practices for reducing food waste and using the fridge or the refrigerator to preserve food for a longer period.
- Comparison to the 50% average (food ends in waste) in Cypriot households.
- Assessing the importance of reducing food waste in Cyprus.
- Main reasons and motives for reducing food waste at the household level.
- Behavior towards ordering prepared food from restaurants (take-away) and taking food that is not consumed in a restaurant or café back home.
- Experience from tv or radio campaigns on the issue of food waste.
- Presence in the household of refrigerator and fridge, compost bin, recycling bins.
- Data for the participants (e.g., age, gender, location, type of house and number of family members).

The survey yields valuable information for promoting food waste reduction in Cyprus. It is not used to estimate food waste amounts, but to capture the behavior of citizens towards food waste.

2.4. Total residential food waste in Cyprus

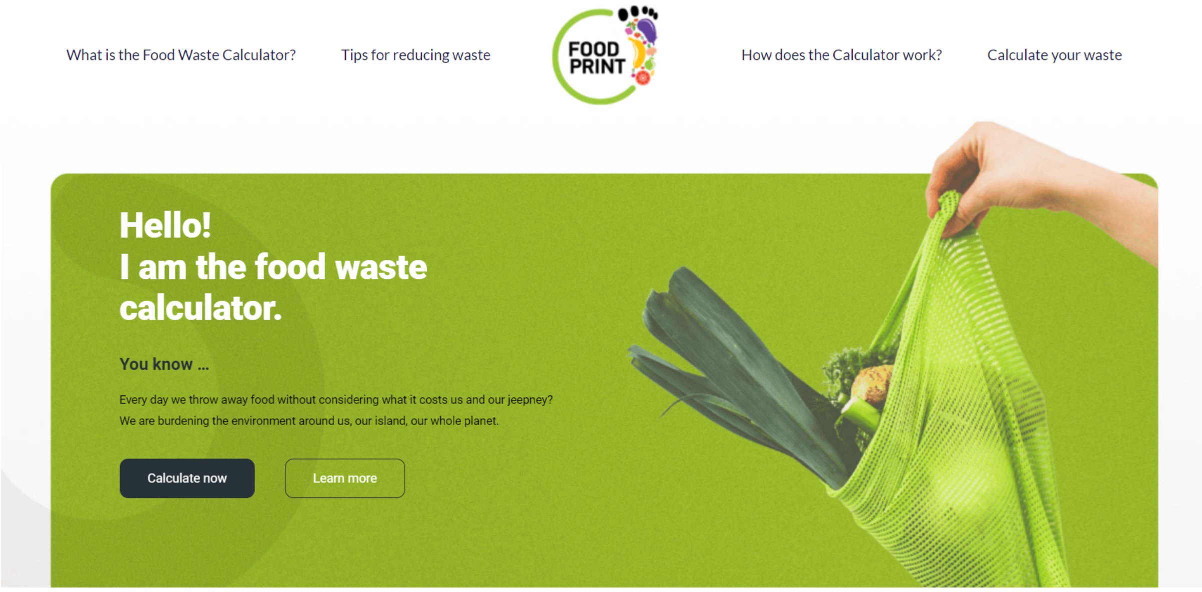
According to data collection in households, food waste quantity per household was estimated after using the 2021 and 2022 data (2 years combined; 2023 data were not used), at the project and national levels. The formula for the estimation was:

AW = FW x W x H (equation 1),

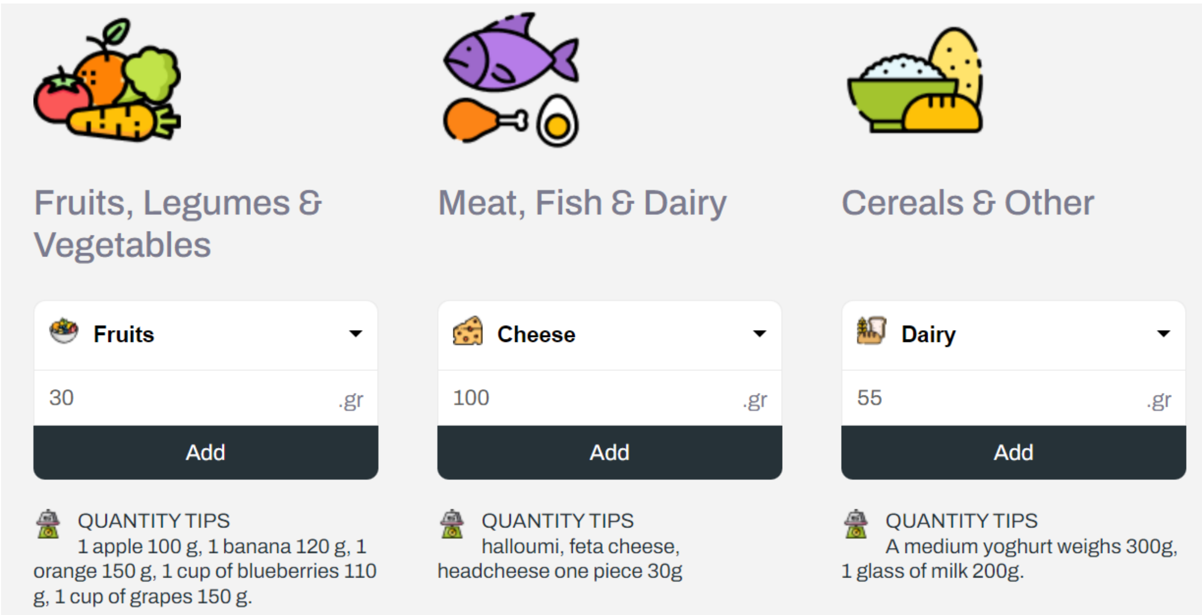
Where AW is the Annual amount of food Waste (kg/year), FW is the amount of Food Waste (kg/week), which was calculated considering the percentage of answers on waste amount per week: a) 0 kg, b) 1-2 kg, c) 2,5-5 kg and d) >5 kg. W is the number of Weeks per year (=52), assuming similar waste production per each week, and H is the number of households in Cyprus, which is obtained from CyStat (CyStat, 2021). The number of households in Cyprus is 371,890, estimated from CyStat data on the 2021 national consensus (CyStat, 2021). For the estimation, the total population (918,100) was used, as well as preliminary data from the 2021 consensus where 221,155 inhabitants were counted and 118,967 houses, from which 75.3% were inhabited (CyStat, 2021).

2.5. The Foodprint Calculator

The project has created an online application the “foodprint CALCULATOR” (see screenshot below).



The calculator offers indicative estimations for the environmental and socioeconomic impact of food waste. It can be used in households (citizens) and in the food and hospitality sector. The methodology for the calculations and the "step by step" instructions for using the tool are presented in a detailed report and will not be repeated here. Briefly, the user selects the food waste categories (e.g., meat, vegetables) and adds the weight wasted during the last 24 h (see screenshot below).



The user receives the impact of the food waste in terms of 1) money lost, 2) meals lost and 3) energy loss per day and per year (assuming that the behavior is repeated for 365 days). The screenshot below presents the outcomes for using the tool to calculate the waste produced due to 100 gr cheese that goes to waste.

The calculator was used during the project and will be continued to be available from the project website. For this report, the data added from 362 users during the period 01/06/2022 to 31/3/2023 were used. The results are presented and analyzed as obtained from the calculator: 1) Money spent in Euros, 2) Meals wasted and 3) mobile phones could be charged and cars that could be taken out of circulation (indirect measurement of GHG emissions. The use of the calculator was for informing the public about the issue of food loss and environmental and socioeconomic impacts.

2.6. Food waste from the food and hospitality sector

This survey was carried out to record food waste from 194 businesses. The profile of the businesses that participated in the survey are hotels (n=10), restaurants (n=100) and café-restaurants (n=20) and bakeries (n=64). It took place in 2020, 2021 and 2022. The aim was to record food waste amounts and assess the impact of LIFEFOODPRINT actions on the behavior of these SMEs. Data collection was challenging during COVID-19 quarantine and relevant restrictions. The following data were collected:

- Number of SMEs per category (e.g., bakeries, hotels) and year (2020, 2021, 2022).
- Food waste amounts per category and year.
- Quantities of cooking oils per category per year.

- Amount of food that goes for charity.

The total number of bakeries, hotels, restaurants and Café-restaurants registered in Cyprus was obtained from the CYSTAT database; Business Register; Number of Enterprises and Employment by Economic Activity (Cystat, 2023). The most recent data from the database is for 2020.

The total amount of food waste (kg) and cooking oil was estimated, per category of companies, for the project and at the national level, after using the data from CyStat. Data on food waste composition were not recorded and the following assumptions were made:

- The food waste from restaurants and hotels has a similar composition to residential.
- The cooking oil is delivered for treatment in specialized companies and environmental impact is not further considered in this report.
- The food waste from cafes is negligible, in comparison to the other three activities (restaurants, bakeries, hotels) and will not be considered in the calculations.

2.7. Food waste estimation from MSW

Data from the Statistical Service regarding Municipal Solid Waste (MSW) production and composition were also employed (CyStat, 2022), to estimate annual organic waste production in Cyprus. Expert opinion and research from LIFEFOODPRINT were also capitalized. Accordingly, 30% of the MSW is considered as food waste (LIFEFOODPRINT). Additionally, we hypothesize that the amount of biodegradable MSW (municipal green spaces organic waste excluded) is related to food waste. Therefore, estimates of annual food waste and per capita were possible.

2.8. Environmental Impacts and benefits

2.8.1. Landfills

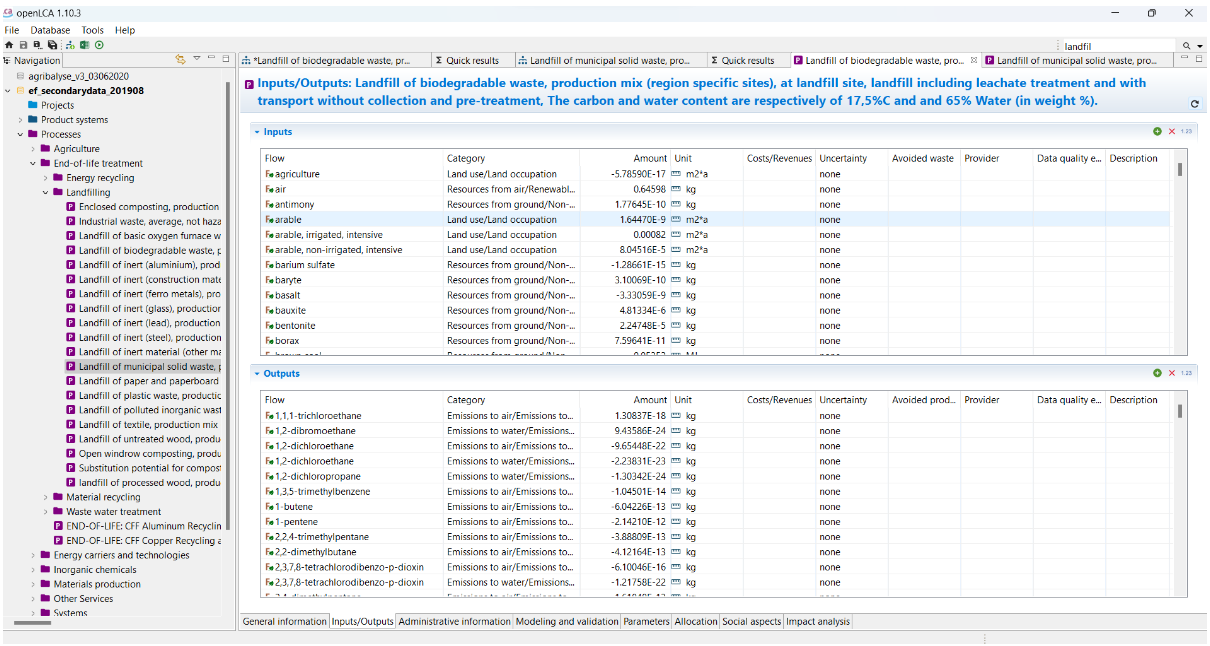
Life Cycle Assessment

The Open LCA software (Figure 1) and EF secondary data (Ciroth, 2007; Recanati and Ciroth, 2019) were used to model landfill processes, using Life Cycle Assessment (LCA).

The landfill characteristics are representative of the EU-28 countries, which is the best data currently available, and the processes used are:

1) Landfill of municipal solid waste, production mix (region specific sites), at landfill site. The carbon and water content are respectively of 30% C and 30% Water (in weight %) – UUID 917d6481-a7a5-42ca-bd66-6b32964ad1ea.
2) Landfill of biodegradable waste, production mix (region specific sites), at landfill site. The carbon and water content are respectively of 17,5%C and 65% Water (in weight %) – UUID 52a86303-7d24-49ba-8161-a1b04dabc4b7.

The processes to build the models are (freely) accessible via the website:
https://nexus.openlca.org/database/Environmental%20Footprints
In the LCA models, the calculations do not include the impacts from waste transport and processing but only the landfill related processes.



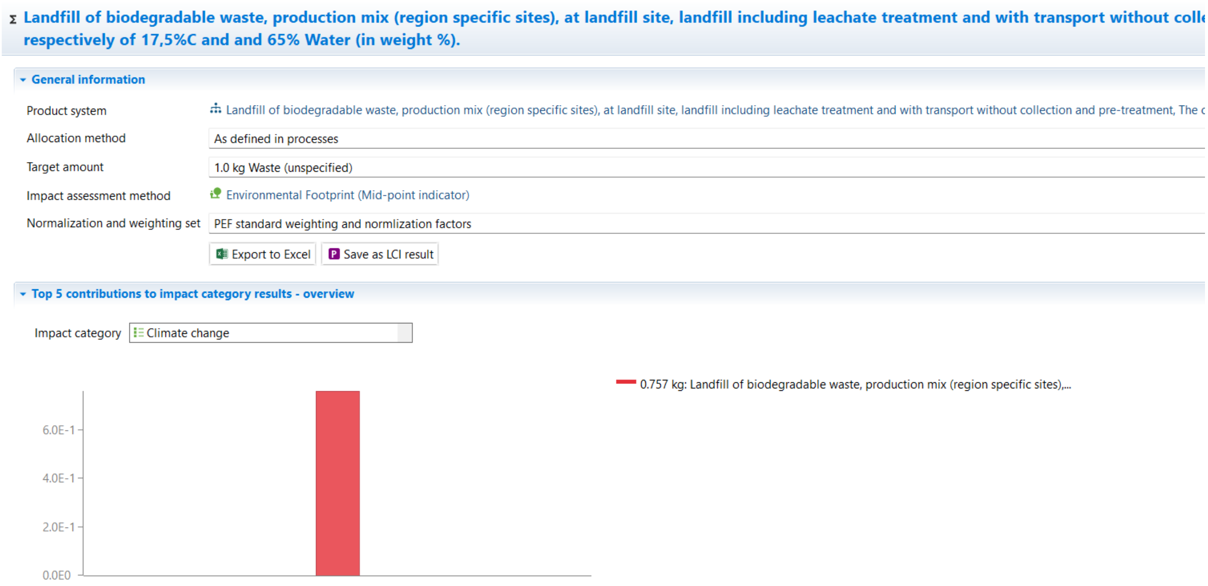


Figure 1. Screenshots from OpenLCA software for the modelling of landfilling MSW and biodegradable SW.

The EF (Environmental Footprints) method was employed, and the following impact categories (Table 1) were used to estimate the environmental impact of food waste landfilling. More information on these indicators can be obtained in Recanati and Ciroth (2019).

Table 1. Impact categories for the LCA according to the Environmental Footprint (Mid-point indicator) method (Recanati and Ciroth, 2019). With bold some of the most recognized indicators.

Impact category	Reference unit
Acidification	mol H+ eq
Climate change	**kg CO_2 eq.**
Climate change-Biogenic	kg CO_2 eq.
Climate change-Fossil	kg CO_2 eq.
Climate change-Land use and land use change	kg CO_2 eq.
Ecotoxicity, freshwater	CTUe
Eutrophication marine	kg N eq
Eutrophication, freshwater	kg P eq
Eutrophication, terrestrial	mol N eq
Human toxicity, cancer	CTUh

Human toxicity, non-cancer	CTUh
Ionising radiation, human health	kBq U-235 eq
Land use	pt
Ozone depletion	kg CFC-11 eq
Particulate Matter	death
Photochemical ozone formation - human health	kg
Resource use, fossils	**MJ**
Resource use, minerals and metals	kg Sb eq
Water use	**m^3 water eq. of deprived water**

2.8.2. Biogas production

Life Cycle Assessment was performed in biogas production, using OpenLCA and the EF database. The model used was the EU-28+EFTA average. The environmental impacts were calculated, using the indicators that are presented in Table 1. The environmental impacts were estimated for producing 1 MJ of energy from waste. Moreover, the data for biogas production from CYPRA (CYPRA, 2023) were used. Accordingly, in 2020, 210,332 tons of organic material yielded 18,330,862 kWh of electricity (plus thermal energy which was not used in our calculations). This results in 87.152 kWh per ton of waste or 313.7473 MJ of energy. Therefore, the environmental impact of biogas production, because of using food waste, was calculated after using the amount of food waste annually in Cyprus (see paragraphs 2.4-2.6) and the respective MJ of energy produced in bioreactors and the impacts of producing 1 MJ of energy in the bioreactor.

2.8.3 Environmental benefits from renewable energy

The environmental benefits from electricity production were estimated by calculating the amount of energy that can be produced after using food waste for biogas production. The data for biogas production from CYPRA (CYPRA, 2023) were used. Accordingly, in 2020, 87.152 kWh were produced per ton of waste added to the bioreactor. The respective environmental benefit comes from reducing the amount of fuel for electricity production in Cyprus. The model for electricity generation in Cyprus was obtained from the EF database, and the OpenLCA software was used.

2.9. GHG emissions mitigation

The GHG emissions mitigation from the project is calculated according to the following equation:

M = L + E – B

Where, M: total GHG emissions mitigation, L: GHG emissions saved due to avoiding landfill for food waste, E are the emissions saved due to energy production in the bioreactor. Finally, B are the emissions due to the bioreactor operation. All the emissions are in tons CO_2eq.

2.10 Awareness to the stakeholders and citizens

The project materialized various information campaigns with the use of:

1) Project website,
2) Project YouTube channel,
3) Social Media (Facebook, Twitter, Instagram, paid ads),
4) e-banners,
5) Online articles (Sigma Live and newspaper),
6) TV appearances/spots/episodes,
7) Newsletters,
8) Print press (magazines, newspapers)

The overall achievements of the dissemination were recorded. In the case of online dissemination, the activity's exposure (i.e., counting the times the activity was projected on people's screens) and the number of people reached by it (i.e., the number of clicks on the activity) were recorded.

2.11. Food waste prevention and environmental benefits

Based on the numbers that the information campaign yielded (see par 2.9), the potential waste prevention is estimated assuming that a number of citizens adopt a zero-food waste attitude. The environmental benefits (GHG emissions mitigation) from avoiding food waste are calculated accordingly, based on average food waste generation per capita and the methods described in paragraph 2.8.

3. Results

3.1. Food purchase

3.1.1. Baseline survey (2021)

Accordingly, in 41 households 586 receipts coming from food purchases were gathered. Additionally, questionnaires (n=33) were obtained, regarding the use of food and food waste. Based on the Receipts the average Household spends € 298 per month on groceries related to food. The categories of expenses were specified corresponding to the receipts gathered, and presented in Figures 2, 3 and 4.

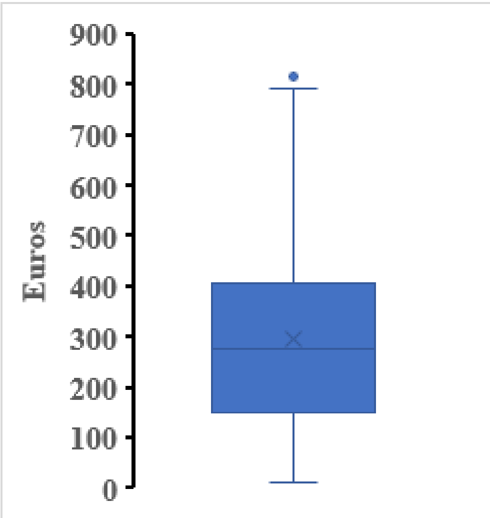


Figure 2. Expenses for food purchase (n=41). Average value (298), median (277), range (11-795) and interquartile range (151-409) are presented in the boxplot (values in Euros per month).

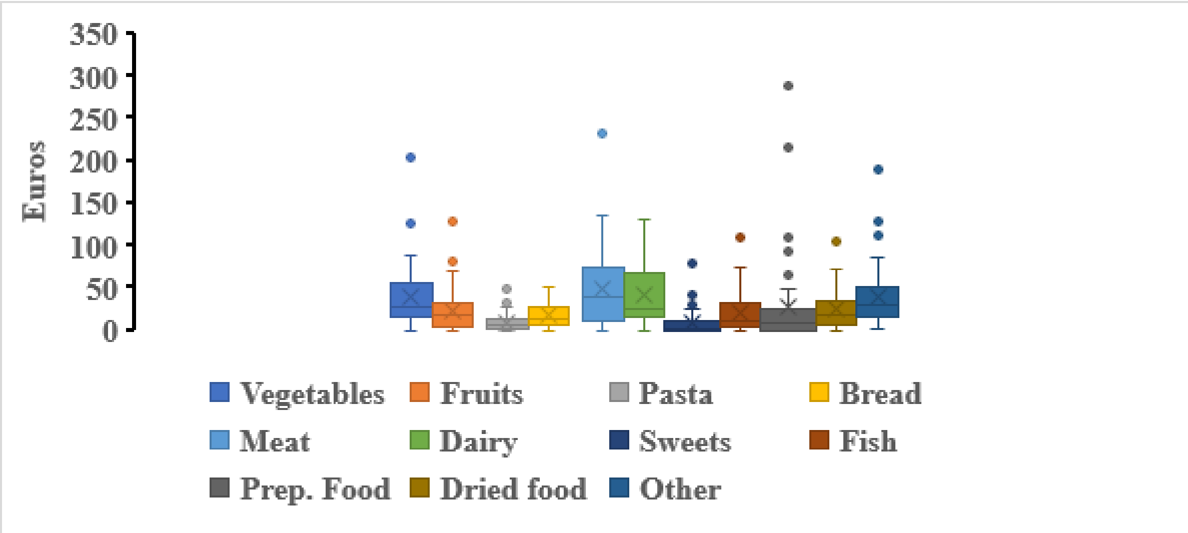


Figure 3. Expenses per food category per month (n=41).

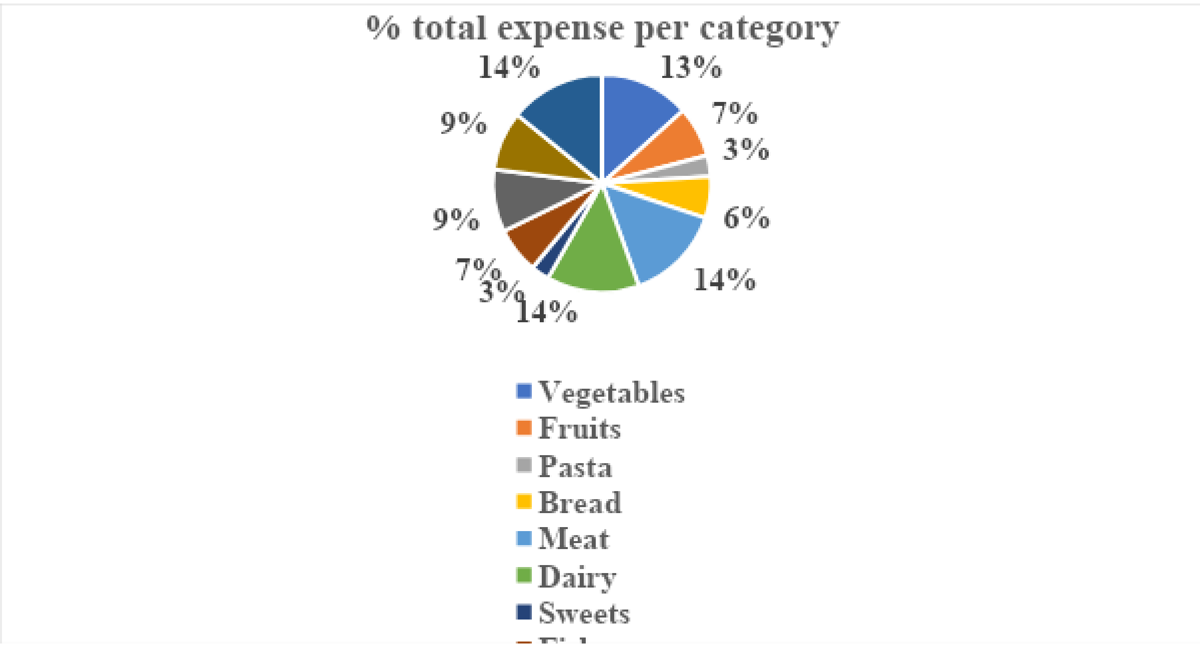


Figure 4. Expenses percentage per food category (n=41).

3.1.2. Midterm survey (2022)

A total of 297 receipts were gathered from a total of 23 Households. From these, 19 answers to the questionnaires were obtained. The people who submitted receipts were anonymous and only identified by a code-name and the responsible person assigned to them from the partner team. The categories of expenses were specified corresponding to the receipts gathered, and presented in Figures 5, 6 and 7.

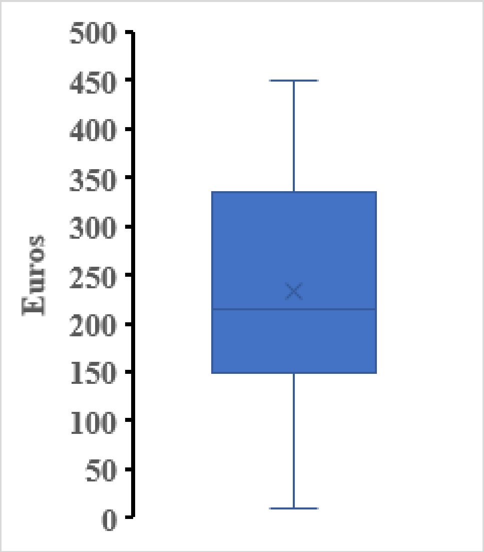


Figure 5. Expenses for food purchase in 2022 (n=23). Average value (233), median (215), range (10-451) and interquartile range (150-336) are presented in the boxplot (values in Euros per month).

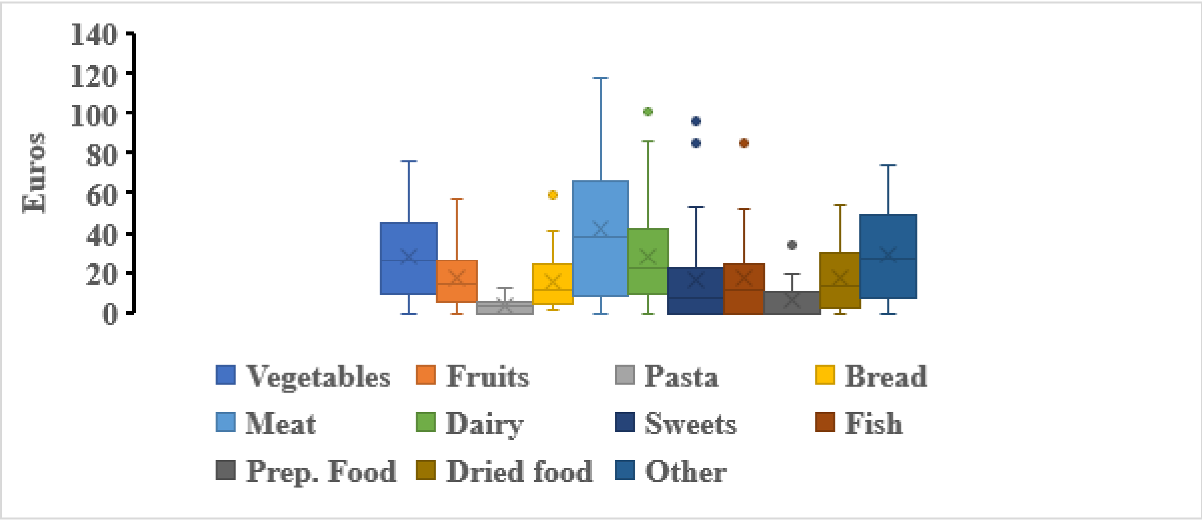


Figure 6. Expenses per food category per month for 2022 (n=23).

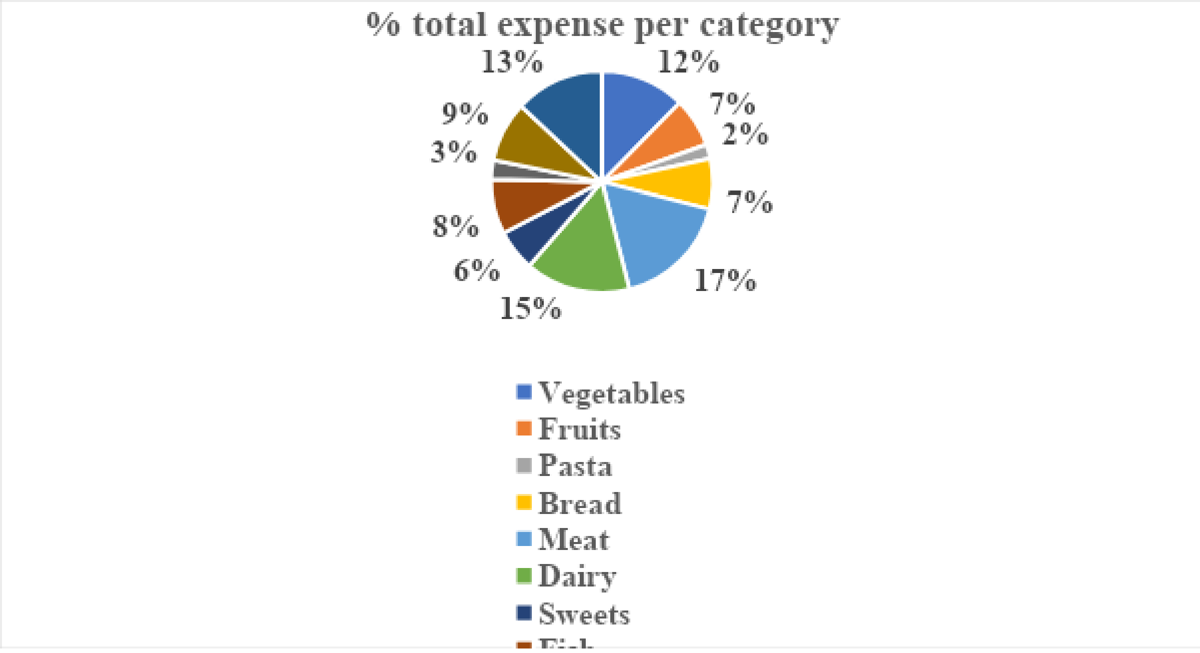


Figure 7. Expenses percentage per food category (n=41).

3.2. Behavior related to food purchase and utilization

The key points related to the survey (see paragraph 2.3) regarding the consumer behavior and food waste, are presented below.

- Seven out of ten consumers tend to buy more than the required quantities of food. These habits may root back into concerns of food security among the population (Figure S1; Supplementary material).
- The main reason food is wasted is because it is not consumed at the expected rate, which is reported to a much greater extent by all participants in the research. To a lesser extent, consumers report that they forget to consume food and that they buy more than they need (Figure S2; Supplementary material).
- Most consumers throw away the food they consider unsuitable for consumption (72%). Three out of ten give this food to pets, while much fewer report that they compost it (Figure S3, Supplementary material).
- The main feeling of consumers when throwing food away, is a feeling of guilt (56%), secondly that of waste of money (46%) and thirdly of concerns for the Environmental impact (30%). One out of ten is completely indifferent (Figure S4, Supplementary material).

- The habit of taking food leftover from outings is more common among those living in other EU countries and the United Kingdom than among those participating from Cyprus or Greece. Among the participants from Cyprus, 18% of them consider it very important to take with them food that is left over after eating out, but do not always do so. Among participants from Greece, it amounts to 16% and among participants from other EU countries and the UK it amounts to 14% (Figure S5, Supplementary material).

For further details, there are respective reports that the project has delivered and are accessible via the project website.

3.3. Food Waste quantities

3.3.1. Residential

According to the baseline and midterm surveys (food purchase in households), the average food waste per week and household was estimated to be 2.469 kg per week. The number was calculated based on data from households, on food waste generation per week. Therefore, 11.8% produce 0 kg; 64.7% 2 kg; 23.5% 5 kg food waste/week (2.469= 0.118*0+0.647*2+0.235*5). This corresponds to 128.39 kg per household per year, assuming equal waste generation for each of the 52 weeks. According to the 2021 census, there are 371890 households in Cyprus (empty or occasionally inhabited houses excluded). Therefore, based on LIFEFOODPRINT survey data, the estimated amount is 47,746,236 kg (or 47,746.24 tons) per year of food waste, coming from residential areas.

3.3.2. Commercial

Table 2 presents the results from a survey in food waste from the commercial sector and Table 3, the estimation for the annual food waste production, using data from the registry of enterprises in Cyprus (number of SMEs). Accordingly, an estimated food waste amount of 110,504 tons/year is attributed to commercial activity.

Table 2. Data on food waste from the commercial sector (LIFE FOODPRINT).

		Waste kg per year			Aver waste kg per entity per year			
Companies	**Number**	**2020**	**2021**	**2022**	**2020**	**2021**	**2022**	**AVER.**
Bakeries	64	880,000	620,000	605,000	13,750	9,688	9,453	10,964
Restaurants	100	160,000	160,000	390,000	1,600	1,600	3,900	2,367
Hotels	10	180,000	620,000	1,170,000	18,000	62,000	117,000	65,667
Cafeterias	20	1,600	2,500	3,500	80	125	175	127

Table 3. Estimated food waste from the commercial sector (all registered SMEs).

Companies	**Total CyStat**	**Tons/year**
Bakeries	1,323	14,505
Restaurants	8,694	20,576
Hotels	1,146	75,254
Cafeterias	1,338	169
Total		**110,504**

3.3.3. LIFEFOODPRINT data on total food waste

According to the project data, the annual amount of food waste is 158,250.28 tons per year (110,504.04 + 47,746.24), as estimated from the data presented in paragraphs 3.3.1-2.

3.3.4. Other estimation approaches for food waste

According to LIFEFOODPRINT desk research and data collection, the annual quantity of food waste (residential and commercial) is equal to 155,000 tons (LIFE FOODPRINT, 2021). Based on 2017-2022 data on MSW production and expert estimation (LIFE FOODPRINT, 2021), 30% of the MSW are food waste, which corresponds to 167,010 tons/year (Table 4). Finally, CySTAT data for annual MSW and composition, deliver an average value (2017-2022) for the biodegradable waste, which could be used as a proxy for food waste, equal to 110,725.2 tons/year (Table 5).

Table 4. Estimated food waste quantities (tons/year), based on MSW and the assumption that 30% is food waste.

Food waste (tons/year)	**167,010.0**
MSW Average	556,699.6
2017	537,490.0
2018	562,100.0
2019	571,073.0
2020	542,835.0
2021	570,000.0

Table 5. Estimated food waste quantities (tons/year), based on MSW biodegradable waste.

Food waste (tons/year)	**110,725.2**
2017	51,190
2018	111,230
2019	132,660
2020	127,118
2021	131,428

Finally, in Figure 8, the estimated amounts of food waste are presented, using expert opinion; hypothesizing that they are 30% of MSW; considering the biodegradable in treatment facilities and after the LIFEFOODPRINT data collection in residential and commercial sectors. The numbers are close, irrespective of the calculation method and allow for an assessment of project impact and the environmental impacts and benefits from waste management practices.

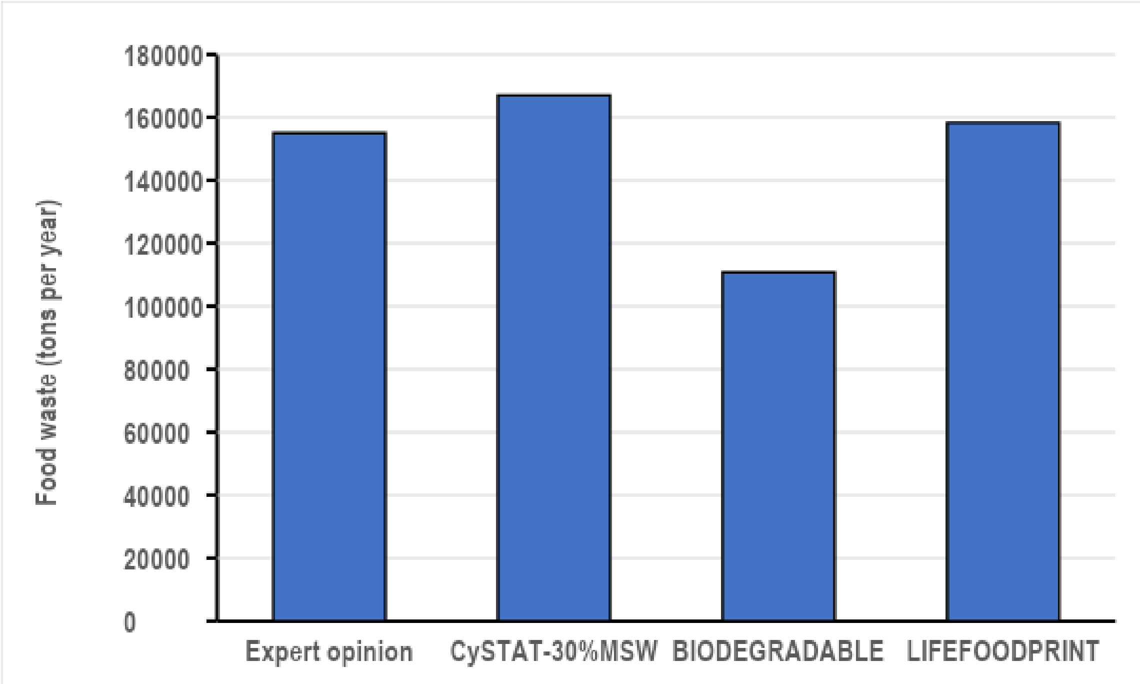


Figure 8. Estimated amounts of food waste in Cyprus according to LIFEFOODPRINT data, expert opinion, and desk research.

3.4. Environmental impacts of landfills

3.4.1. Municipal Solid Waste

In Table 6, the environmental impacts from MSW landfills are presented while in Table 7 the respective annual values are given for the total MSW (food waste plus other categories) produced in Cyprus.

Table 6. Environmental impacts of landfills in the case of MSW. The values are per kg of waste landfilled.

Impact category	Reference unit	Value
Acidification	mol H+ eq	0.2×10^{-3}
Climate change	kg CO2 eq.	1.06
Climate change-Biogenic	kg CO2 eq.	0.94
Climate change-Fossil	kg CO2 eq.	0.12
Climate change-Land use and land use change	kg CO2 eq.	0.1×10^{-3}
Ecotoxicity, freshwater	CTUe	1.1×10^{-3}

Eutrophication marine	kg N eq	0.3×10^{-3}
Eutrophication, freshwater	kg P eq	0
Eutrophication, terrestrial	mol N eq	0.001
Human toxicity, cancer	CTUh	0
Human toxicity, non-cancer	CTUh	0
Ionising radiation, human health	kBq U-235 eq	na
Land use	pt	0.03
Ozone depletion	kg CFC-11 eq	0
Particulate Matter	death	0
Photochemical ozone formation - human health	kg	0.6×10^{-3}
Resource use, fossils	MJ	na
Resource use, minerals and metals	kg Sb eq	0
Water use	m3 water eq. of deprived water	na

na: not applicable

Table 7. Environmental impacts of landfills in the case of MSW. The values are for the total amount of municipal solid waste landfilled annually in Cyprus.

Impact category	Reference unit	Value
Acidification	mol H+ eq	103,350
Climate change	kg CO2 eq.	587,447,967
Climate change-Biogenic	kg CO2 eq.	523,347,032
Climate change-Fossil	kg CO2 eq.	64,035,129
Climate change-Land use and land use change	kg CO2 eq.	65,806
Ecotoxicity, freshwater	CTUe	6,195,120
Eutrophication marine	kg N eq	151,422
Eutrophication, freshwater	kg P eq	0
Eutrophication, terrestrial	mol N eq	576,343
Human toxicity, cancer	CTUh	0
Human toxicity, non-cancer	CTUh	0
Ionising radiation, human health	kBq U-235 eq	na
Land use	pt	15,850,681
Ozone depletion	kg CFC-11 eq	na
Particulate Matter	death	0

Photochemical ozone formation - human health	kg	339,451
Resource use, fossils	MJ	na
Resource use, minerals and metals	kg Sb eq	na
Water use	m3 water eq. of deprived water	na

Regarding CO_2 emissions, the amount produced by landfilling annually (= 0.587 Million tons CO2; Table 7) is estimated to be 7.7% of the total country emissions (7.6 Million tons; Ourworldindata.org) . Considering the average emissions from a passenger (diesel) car equal to 0.127 kg per km, the emissions due to landfills operations are equivalent to 4,625 billion kilometers. This is equal to the emissions produced by 231,278 cars, if each of them travels 20,000 km per year.

3.4.2. Food waste landfills

In Table 8, the environmental impacts from food waste landfills are presented while in Table 9 the respective annual values are given for the total food waste produced in Cyprus. The data presented in Table 9 show the mitigation potential in the case that all food waste is diverted in a landfill for biodegradable waste (and not taken into MSW landfills).

Table 8. Environmental impacts of (organic material) landfills. The values are per kg of waste landfilled.

Impact category	Reference unit	Value
Acidification	mol H+ eq	0.2×10^{-3}
Climate change	kg CO2 eq.	0.76
Climate change-Biogenic	kg CO2 eq.	0.67
Climate change-Fossil	kg CO2 eq.	0.09
Climate change-Land use and land use change	kg CO2 eq.	0.1×10^{-3}
Ecotoxicity, freshwater	CTUe	5.2×10^{-3}
Eutrophication marine	kg N eq	0.4×10^{-3}
Eutrophication, freshwater	kg P eq	0
Eutrophication, terrestrial	mol N eq	1×10^{-3}

Human toxicity, cancer	CTUh	0
Human toxicity, non-cancer	CTUh	0
Ionising radiation, human health	kBq U-235 eq	na
Land use	pt	0.07
Ozone depletion	kg CFC-11 eq	0
Particulate Matter	death	0
Photochemical ozone formation - human health	kg	0.5×10^{-3}
Resource use, fossils	MJ	0.35
Resource use, minerals and metals	kg Sb eq	0
Water use	m3 water eq. of deprived water	0

Table 9. Environmental impacts of landfills in the case of food waste (biodegradable) landfilling. The values are for the total amount of waste landfilled annually in Cyprus.

Impact category	Reference unit	Value
Acidification	mol H+ eq	36,147
Climate change	kg CO2 eq.	119,786,064
Climate change-Biogenic	kg CO2 eq.	105,338,454
Climate change-Fossil	kg CO2 eq.	14,427,328
Climate change-Land use and land use change	kg CO2 eq.	20,281
Ecotoxicity, freshwater	CTUe	821,879
Eutrophication marine	kg N eq	60,844
Eutrophication, freshwater	kg P eq	0
Eutrophication, terrestrial	mol N eq	157,565
Human toxicity, cancer	CTUh	0
Human toxicity, non-cancer	CTUh	0
Ionising radiation, human health	kBq U-235 eq	na
Land use	pt	11,616,798
Ozone depletion	kg CFC-11 eq	0
Particulate Matter	death	0
Photochemical ozone formation - human health	kg	79,471
Resource use, fossils	MJ	na

Resource use, minerals and metals	kg Sb eq	na
Water use	m3 water eq. of deprived water	0

Regarding CO_2-eq emissions from food waste, the amount produced by landfilling annually is equal to 1.6% of annual country emissions.

In Figure 9, the contribution of residential and commercial food waste to the GHG emissions produced is presented.

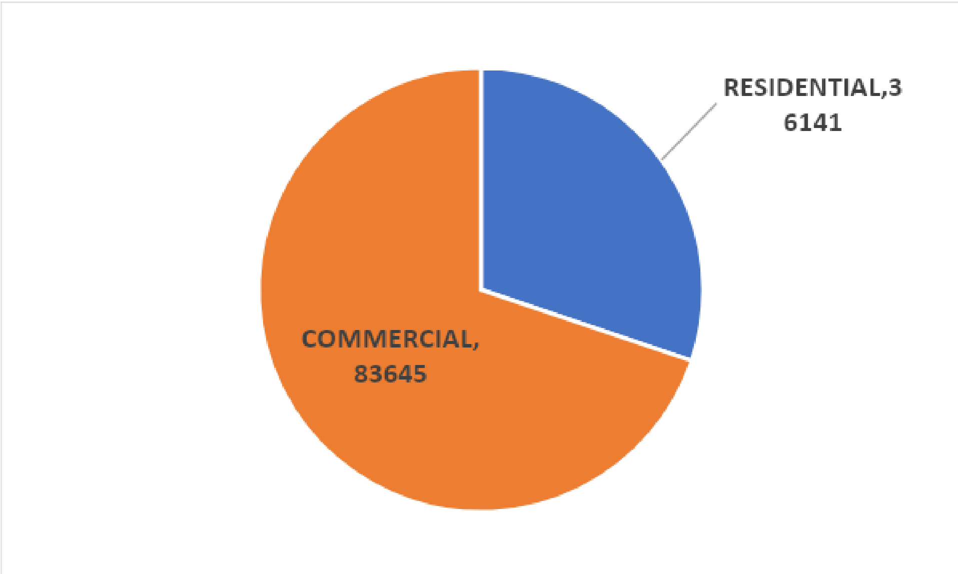


Figure 9. GHG emissions in Tons CO2-eq due to food waste landfilling, for residential and commercial sources and according to the LIFEFOODPRINT data on waste production.

3.5. Biogas production

In Table 10, the environmental impacts of biogas production are presented, per ton of organic waste used. In Table 11, the total impacts of biogas production after utilizing 158,250.28 tons of food waste are presented.

Table 10. Environmental impacts of biogas production, per 1 ton of waste used to produce electricity.

Impact category	Reference unit	Value
Acidification	mol H+ eq	0.01

Climate change	kg CO2 eq.	5.10
Climate change-Biogenic	kg CO2 eq.	0.34
Climate change-Fossil	kg CO2 eq.	4.75
Climate change-Land use and land use change	kg CO2 eq.	0.01
Ecotoxicity, freshwater	CTUe	0.92
Eutrophication marine	kg N eq	0.007
Eutrophication, freshwater	kg P eq	0.0003
Eutrophication, terrestrial	mol N eq	0.062
Human toxicity, cancer	CTUh	0
Human toxicity, non-cancer	CTUh	0
Ionising radiation, human health	kBq U-235 eq	0.489
Land use	pt	619.45
Ozone depletion	kg CFC-11 eq	0
Particulate Matter	death	0
Photochemical ozone formation - human health	kg	0.014
Resource use, fossils	MJ	57.03
Resource use, minerals and metals	kg Sb eq	0
Water use	m3 water eq. of deprived water	na

Table 11. Environmental impacts of biogas production, for all the food waste produced annually in Cyprus.

Impact category	Reference unit	Value
Acidification	mol H+ eq	3,084
Climate change	kg CO2 eq.	807,785
Climate change-Biogenic	kg CO2 eq.	53,995
Climate change-Fossil	kg CO2 eq.	752,058
Climate change-Land use and land use change	kg CO2 eq.	1,731
Ecotoxicity, freshwater	CTUe	145,947
Eutrophication marine	kg N eq	1,053
Eutrophication, freshwater	kg P eq	52.76
Eutrophication, terrestrial	mol N eq	9,852
Human toxicity, cancer	CTUh	0

Human toxicity, non-cancer	CTUh	0
Ionising radiation, human health	kBq U-235 eq	77,299
Land use	pt	98,028,984
Ozone depletion	kg CFC-11 eq	0
Particulate Matter	death	0
Photochemical ozone formation - human health	kg	2,267
Resource use, fossils	MJ	9,024,348
Resource use, minerals and metals	kg Sb eq	0
Water use	m3 water eq. of deprived water	na

3.6. Energy production

According to data from a bioreactor in Cyprus (CYPRA), 87.152 kWh per ton of waste can be produced. The amount of food waste is estimated to be 158,250.28 tons/year. Therefore, the electricity that can be produced each year from food waste is equal to 13,791,828.59 kWh. Electricity (total) consumption in Cyprus is estimated to 4.61×10^9 kWh per year (IEA, 2020). Electricity consumption per capita is estimated to be 3,700 kWh/year (Enerdata, 2021). Therefore, electricity production due to food waste use could cover the annual needs of approximately 3728 people.

3.7. Environmental benefits from renewable energy

The electricity production system in Cyprus uses mainly heavy fuel oil (HFO). The impacts per kWh are presented in Table 12. Table 13, presents the benefits of producing electricity from food waste, thus reducing the dependence on HFO.

Table 12. Environmental impacts of electricity production from HFO, per kWh.

Impact category	Reference unit	Value
Acidification	mol H+ eq	6.35×10^{-3}
Climate change	kg CO2 eq.	0.912
Climate change-Biogenic	kg CO2 eq.	0
Climate change-Fossil	kg CO2 eq.	0.912

Climate change-Land use and land use change	kg CO2 eq.	0
Ecotoxicity, freshwater	CTUe	0.224
Eutrophication marine	kg N eq	0.54×10^{-3}
Eutrophication, freshwater	kg P eq	0
Eutrophication, terrestrial	mol N eq	5.93×10^{-3}
Human toxicity, cancer	CTUh	0
Human toxicity, non-cancer	CTUh	0
Ionising radiation, human health	kBq U-235 eq	0.31×10^{-3}
Land use	pt	0.022
Ozone depletion	kg CFC-11 eq	0
Particulate Matter	death	0
Photochemical ozone formation - human health	kg	1.89×10^{-3}
Resource use, fossils	MJ	11.21
Resource use, minerals and metals	kg Sb eq	0
Water use	m3 water eq. of deprived water	0.069

Table 13. Environmental benefits from reducing HFO dependence due to electricity production from food waste (bioreactors).

Impact category	**Reference unit**	**Value**
Acidification	mol H+ eq	87,549
Climate change	kg CO2 eq.	12,576,723
Climate change-Biogenic	kg CO2 eq.	0
Climate change-Fossil	kg CO2 eq.	12,576,723
Climate change-Land use and land use change	kg CO2 eq.	0
Ecotoxicity, freshwater	CTUe	3,092,420
Eutrophication marine	kg N eq	7,420
Eutrophication, freshwater	kg P eq	0
Eutrophication, terrestrial	mol N eq	81,753
Human toxicity, cancer	CTUh	0
Human toxicity, non-cancer	CTUh	0
Ionising radiation, human health	kBq U-235 eq	4,288
Land use	pt	309,708

Ozone depletion	kg CFC-11 eq	0
Particulate Matter	death	0
Photochemical ozone formation - human health	kg	26,052
Resource use, fossils	MJ	154,592,883
Resource use, minerals and metals	kg Sb eq	0
Water use	m3 water eq. of deprived water	953,180

3.8. GHG emissions mitigation

The GHG emissions mitigation potential of the project is calculated to be 131,555,001.14 (=12,576,723.57+119,786,064-807,785.86) kg CO_2eq per year. This figure is estimated according to the following:

- 12,576,723.57 kg CO_2eq per year due to renewable energy (avoid HFO dependence).
- 119,786,064 kg CO_2eq per year due to reducing landfill waste.
- Emissions equal to 807,785.86 CO_2eq per year due to bioreactor operation.

The total CO2 savings equals 0.132 million tons per year, which is 1.73% of annual national emissions.

3.9. Foodprint calculator results

Citizens (362) participated in the survey during the period June 2022 – March 2023. They added data on the food waste they generate daily (food waste produced during the last 24 hours). The results of this survey are presented in the following Figures (10-15). Briefly, money lost per person is 3.18 and 1001.35 euro per day and year, respectively. Meals lost per person are 1.92 and 233.88 per day and year. If food waste per person is converted to energy it could charge 651 mobile phones per year (approx. 2 times per day). Finally, the GHG emissions produced by food waste (per person and per year) are estimated equal to that produced by 0.4 passenger cars (car emissions for 20,000 km travel at a yearly basis).

Figure 10. Money loss due to food waste in euros per person per day (n=362). Average value (3.18), median (3.16), range (1.46-4.63) and interquartile range (2.62-3.96) are presented in the boxplot.

Figure 11. Money loss due to food waste in euros per person per year (n=362). Average value (1001.35), median (1046.80), range (480.58-1350.22) and interquartile range (832.48-1210.45) are presented in the boxplot.

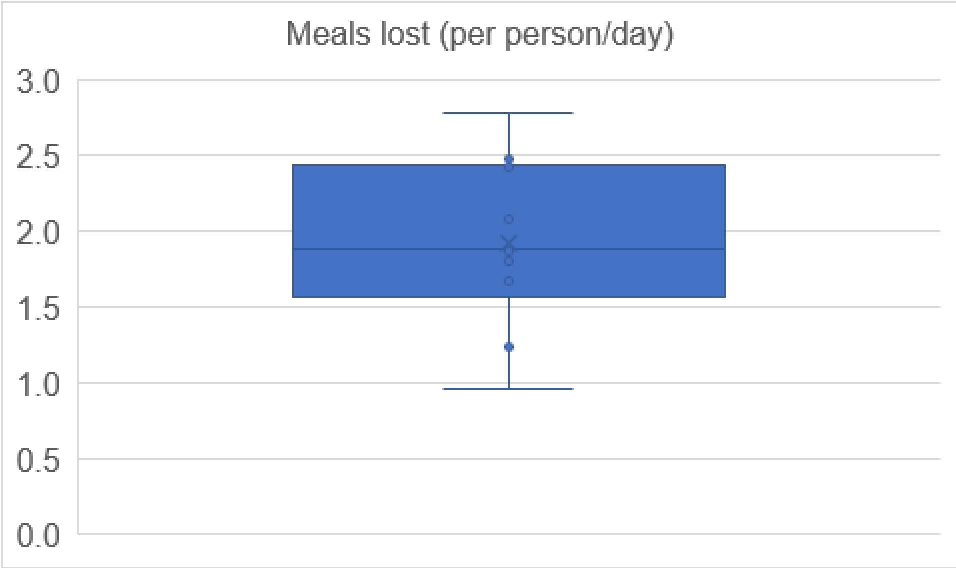


Figure 12. Meals loss due to food waste in euros per person per day (n=362). Average value (1.92), median (1.88), range (1.56-2.44) and interquartile range (1.56-2.44) are presented in the boxplot.

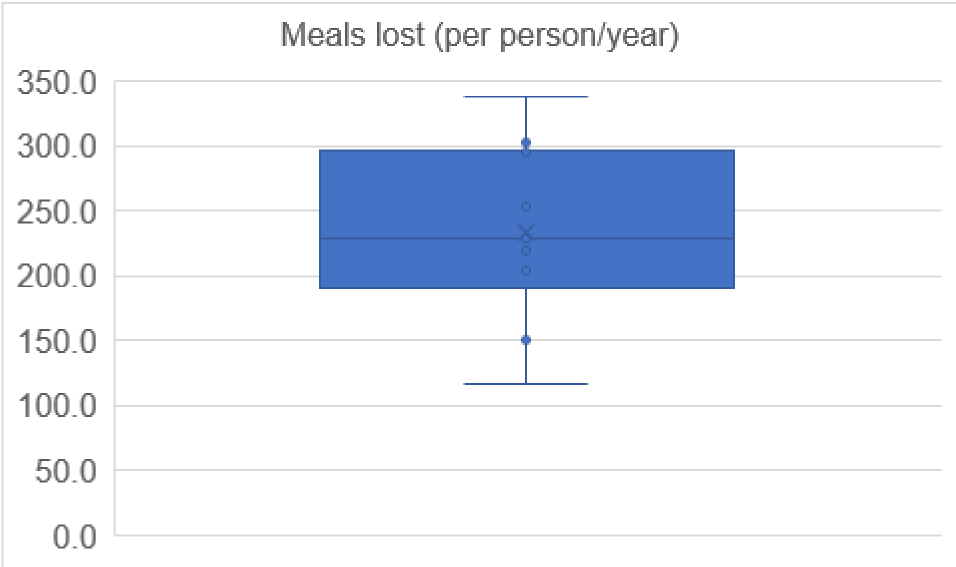


Figure 13. Meals loss due to food waste in euros per person per year (n=362). Average value (233.88), median (228.74), range (116.58-338.42) and interquartile range (190.47-297.42) are presented in the boxplot.

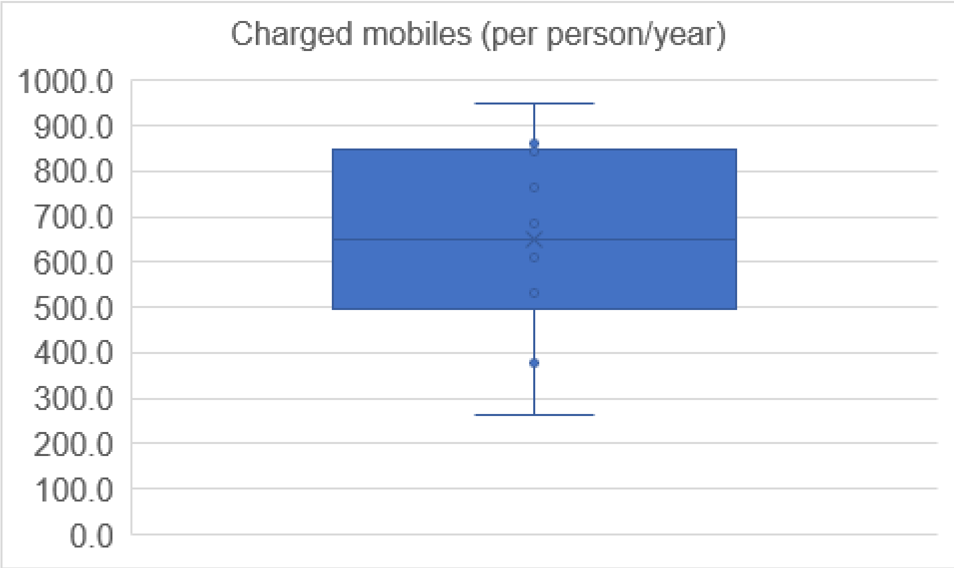


Figure 14 Charged mobiles (food waste to energy) per person per year (n=362). Average value (650.48), median (650.60), range (262.79-949.82) and interquartile range (495-847) are presented in the boxplot.

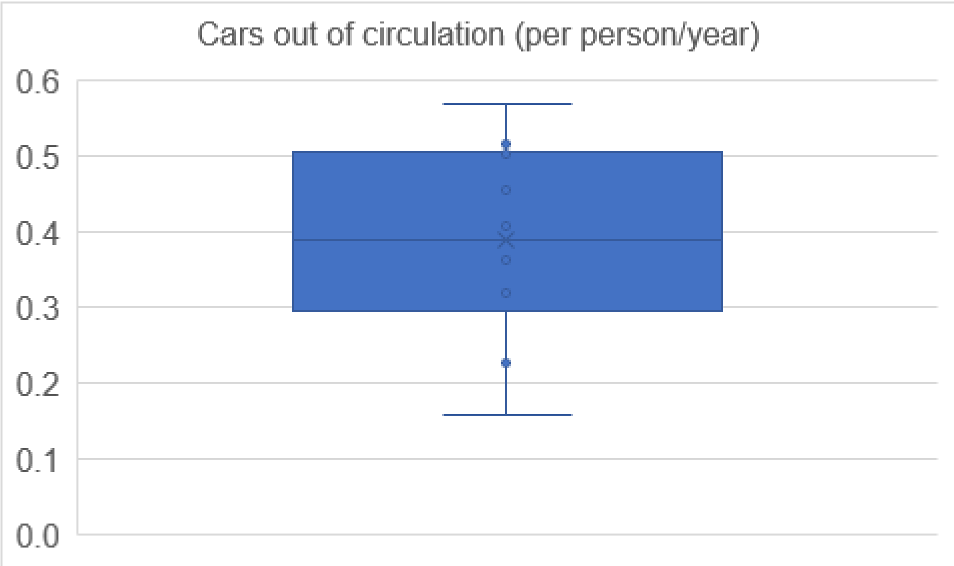


Figure 15. Cars out of circulation per person per year (GHG emissions due to food waste; equivalence to passenger cars emissions). Average value (0.39), median (0.39), range (0.16-0.57) and interquartile range (0.30-0.51) are presented in the boxplot (n=362).

3.10. Awareness to the stakeholders and citizens

In Table 14, the results related to the dissemination campaign for the project LIFE FOODPRINT are presented in detail.

3.11. Food waste prevention

According to the results of Table 14, more than 800,000 people have interacted and possibly been informed about the project through a broad communication campaign, involving online, press, radio and TV medium. Following a more conservative approach we assume that 100,000 citizens (1 in 8) considered the option to zero food waste.

The estimated food waste production per year in Cyprus is 158,250.28 tons/year (LIFE FOODPRINT data) and the population in the Government controlled areas of Cyprus on the 1st of October 2021 was 918,100 citizens. This results in 172.37 kg of food waste per capita per year. The equivalent food waste reduction resulting from 100,000 citizens is 17,237 tons. The GHG emissions mitigation (due to avoiding landfilling) in this case is estimated to be 13,046.69 tons CO_2.

3.12. LIFE FOODPRINT KPIs

The results of the current report were used to evaluate Key Project Indicators (KPIs) at the end of the project. Table 15 presents those values, based on the material provided, within this report, along with comments on how each value was estimated.

Table 14. Results of the project dissemination campaign.

Mean of dissemination		*Exposure (Exp.)*	*Reached (Rea.)*	*Number (eg. spots /articles)*	*Comment*
Website		73,117	53,442		Exp.: number of visits – Rea.: number of unique visitors
Facebook page		246,172	665		Exp.: total number of users reached through posts - Rea.: Number of Followers
Instagram page		171,542	473		
Twitter		20,962	62		
Youtube channel		5,952	662	46	Exp.: number of exposures of the video on people's screens. Rea.: number of people who viewed the youtube video
Web banners		10,467,466	7,740	14	Exp.: The number of exposures of the web banner on people's screens. An ad can be exposed multiple times to the same person. Rea.: number of clicks on the web banner ad
Informational material		9,863		9.863	Informational material (e.g. brochures, notepads, pens, posters, bags) distributed broadly through relevant activities.
Newsletters			3,448	69	The average number of people reached
Online Articles	Simerini		948	20	Exp.: The average readership for the printed press. Rea.: The number of people who purchase the newspaper/magazine
	Sigmalive		6,881	80	
Print press	Economy today	130,777	144	5	
	Madame Figaro	221,875	880	2	
	Simerini	30,228	529	2	
	Other			7	Articles at Philelephteros, Politis, Agrotis, Brief
TV programs	Cooking class	40,000	19,886		The average number of people who watched the TV programme, based on TV ratings of the time and programme
	Πρωτοσέλιδα		31,052		
	Μεσημέρι και κάτι		27,445		

	Τομές στα γεγονότα		53,935		
	Ήρθε και έδεσε		15,536		
Campaign	TV spots		490,392	362	The average number of people who watched the TV spot, based on TV ratings at the time of the spot. Cumulative number of people that watched the TV spots
	Facebook/Instagram (A,B,C)	2,357,400	11,700		Exp.: The number of exposure of the ad on people's screens. An ad can be exposed multiple times to the same person. Rea.: the number of people that clicked on the ad
	Google (A,B,C)	13,660,000	28,716		
Surveys			1,906		The average number of people who participated in the 3 surveys
Total		**43,312,114**	**804,445**	**10,463**	

Table 15. Project's impact as explained through selected Key Project Indicators (KPIs).

CODE	NAME	DESCRIPTOR	END VALUE	UNIT	COMMENTS
1.5	Project area/length	Area of environmental implementation actions	9,251	km2	The awareness campaign has taken place all over the country
1.6	Humans (to be) influenced by the project	Persons with improved capacity or knowledge due to project actions	8,000	Number of persons	Participants in the project activities such as consultations, trainings, seminars, and other events. This is close to 1% of the people reached (see Table 14).
		Persons who changed their behaviour or practices due to the project actions	100,000	Number of persons	Persons reached through all the activities of the project and who have changed their behaviour related to the food waste (i.e. following good practices, etc.). This is a conservative estimate from the persons influenced (see below).
		Persons who may have been influenced via dissemination or awareness raising project-actions (reaching)	804,445	Number of persons	People reached through all project activities and dissemination campaign. (e.g. printed press, radio, TV, popular web-portals). Linked with people reached as indicated in table 14
3.1	Waste management - Waste from agriculture, horticulture, aquaculture, forestry, hunting and fishing, food preparation and processing	Mass of non-appropriately managed waste	17,237	tn/year	Mass reduction due to recycling: Based on the current situation, recycling of food waste is done at the biogas plant with Anaerobic digestion and the material comes directly from businesses (returns and expired products from retail shops, materials from catering facilities,

CODE	NAME	DESCRIPTOR	END VALUE	UNIT	COMMENTS
					bakeries etc.). The value is estimated after adoption of the zero food waste approach from 100,000 citizens in Cyprus.
		a. Mass reduction due to waste prevention	17,237	tn/year	Same as above.
		c. Mass reduction due to recycling	3,200	tn/year	This is the organic waste delivered in the digester per year, according to reporting from the company CYPRA that runs the facility.
8.1.1	CO2	Unspecific private (private responsibility)/ bottom-up change of habits	16,988.78	Tons of CO2 /year	Calculated based on 3200 tons of food waste delivered in the digester. Landfill CO2: 3200 tons x 0.7569 tons CO2 per ton of food waste = 2442.08 tons CO2. Benefits from electricity production (avoid HFO use): 3200 tons x 87.152 kWh per ton = 278,886.4 kWh and 1 kWh produces 0.9119 kg CO2. Therefore, 254,316.5 kg (254.32 tons) CO2 saved due to electricity production in the digester and avoiding HFO use. Finally, 16.334 tons of CO2 are emitted due to digester operation. CO2: 2422.08 + 254.32 – 16.334 = 2660.07 tons CO2/year Plus 100,000 citizens select the zero-food waste option. Which leads to 17,237 food waste diverted from landfills. Following a similar approach for the calculation, as above, the CO2 savings are estimated to be 14,328.71 tons CO2.
		Unspecific private (private responsibility)/ bottom-up change of habits	18.5	kg CO2/person	On a country level (918,100 citizens). 16,988.78 tons CO2/year divided by the population in the island.
8.1.2	Other greenhouse gases	CH4	667.38	Tons of GHG /year	Based on previous assumptions, the potential reduction of mismanaged waste is 17,237 tons per annum. Also, based on a recent study of the Cyprus Biogas Association (Waste operators) and OEB, the existing biogas plants can accept maximum 132.000 tons/year organic/biodegradable Food waste. So in terms of savings in GHG emissions from the reduction of mismanaged waste 17,237 ton/year x (90m3biogas)/ton x 60/100=930,798 m3CH4/year can be saved Density of CH4 is 0.717 (kg CH4)/m3. Therefore 667,382.166 kg of CH4 could be saved.

CODE	NAME	DESCRIPTOR	END VALUE	UNIT	COMMENTS
		CH_4	0.727	kg GHG/person	667,382.166 kg of CH_4 / 918,100 citizens in Cyprus
10.2	Involvement of non-governmental organisations (NGOs) and other stakeholders in project activities	Public body/bodies	473	number of individuals	Public bodies such as Government departments and/or ministries (Ministry of Education and Culture, Pedagogical Institute, Ministry of Agriculture, Rural development and Environment, Office of the Commissioner for the Environment, the Office of the Commissioner volunteering, local authorities, local Development Agencies). The aforementioned individuals were involved in the consultations in action B2.1 (57), in the seminars of B3.4 (414) and in the press conferences of the project but also through their involvement in educational activities as were the workshops to students and to children.
		NGO	38	number of individuals	38 NGO's were engaged throughout the duration of the project through the consultations of B2.1, the stakeholder meetings for B1.1., and the networking events of the project in D2.2. They provided valuable insights for the report which was created following the consultations and how the collaboration platform can become a tool which is of use to the civic space.
		Other	20	number of individuals	Media organizations/journalists participated in the project activities (e.g. press conference, etc.). The number refers to individuals, who were participants at the two press conferences and networking activities as was B1.3 and C2.2 as was the workshop FoE did educating journalists on environmental matters. Journalists represented big media companies/bodies as is Dias, Alpha, Rik, Omega, Ant1 and freelance journalists.
		Volunteers	85	number of individuals	85 Volunteers participated in the Household Baskets of C1.4 and the collection of data for the Foodprint Calculator
		Other civil society organisations	25	number of individuals	CSO's were reached to share the informational material and results of the project by the consortium throughout the project. Their direct involvement was in the development of the Collaboration platform and the Networking Activities.
		Private for profit	176	number of individuals	Restaurants, hotels, and other food and hospitality businesses in Cyprus. They were reached mainly through OEB's network, and were engaged in the consultations B2.1, as participants in the workshops for professionals of the F&H sector, participants of the two Foodprint awards and networking activities in D2.2.

CODE	NAME	DESCRIPTOR	END VALUE	UNIT	COMMENTS
11.1	Website (mandatory)	No. of unique visits	53,442		Number of unique website visits
		Other distinct media products created (e.g. different videos/broadcast/leaflets)	10,463	Number of outcomes (e.g. nr of reports, events, etc)	The number of developed Youtube videos, web banners, newsletters, leaflets, brochures, notepads, pens, online articles etc. Linked with the number of activities (e.g spots/articles) as indicated in table 14
11.2	Other tools for reaching/raising awareness of the public	Number of different publications made (Journal/conference)	3	Number of outcomes	Three reports were produced through the Public surveys which were conducted at the beginning, middle, and end of the project. Out of these reports academics were approached to publish research papers, from which two interested parties have informed the consortium that they will be writing research papers. Additionally, there was one participation in a conference by OEB and FoE, but did not have a publication linked to that participation.
		Number of events/exhibitions organised	9	Number of outcomes (e.g. nr of reports, events, etc)	2 live-links, 1 info-table, 1 Environmental festival, 2 press conferences, 2 awards and 1 networking event. The awards will continue to be done after the end of the project.
		Number of articles in print media (e.g. newspaper and magazine articles)	28	Number of outcomes (e.g. nr of reports, events, etc	22 Articles in a nationwide newspaper Simerini and six articles in other magazines/newspapers.
11.3	Surveys carried out regarding awareness of the environmental/climate problem addressed (only mandatory for information and awareness projects)	Individuals	2,245	number of individuals surveyed	Average number of responders in 3 structural questionnaires (538) Average number of responders in 12 online polls (1365) Numbers of participants in the survey conducted for the Foodprint Calculator (45) Number of participants on the survey conducted for the household basket of C1.4 (68) Number of participants of the final evaluation surveys as part of B2.2 (229).

CODE	NAME	DESCRIPTOR	END VALUE	UNIT	COMMENTS
		Other	33	number of individuals surveyed	Surveys to be collected from stakeholders/businesses
		Number of people used the Foodprint calculator	362	Number of people	Participated in data collection and footprint estimation, during the period June 2022 to March 2023.
12.1	Networking (mandatory)	Members of interest groups / lobby organisations	815	No. of individuals	14 discussions with working groups in Cyprus - 504 people, six discussions with EU working groups- 39 participants, 2 study visits, 4 networking events, 11 e-meetings with a total of 158 participants, 18 Consultations had a total of 87 participants, One networking event (B1.3) 27 participants. Total number=815
12.2	Professional training or education	Students (in higher education)	205	No. of individuals	10 seminars
		Professionals - experts in the field	106	No. of individuals	4 workshops were implemented during the project. The best practice guide was developed and distributed in all trainings and presented in the trainings for students. The educational material and the best practice guide will be used for future trainings of OEB.
		Pupils (of school age)	5,153	No. of individuals	13 interactive lessons, which were implemented in 2022 and 2023. In 2022 149 workshops took place and in 2023 134 workshops.
13	Jobs	Jobs	3	No. of FTE	FTE = Total person months of new personnel (hired for the needs of the project / project duration in months.

4. Conclusions

The LIFE FOODPRINT project sought to increase cooperation among the stakeholders in relation to this environmental issue by educating, informing, and raising awareness of it. This report's key subjects include food waste production, environmental impacts, food waste prevention, and environmental benefits and awareness for entities and citizens. Its goal is to offer information about the project's environmental impact.

The following are the report's main conclusions:
It is crucial for the Cypriot society to **raise awareness** about the problem of food waste because it has the potential to significantly reduce food waste. Targeted food buy campaigns should emphasize the problems of overconsumption that result in food waste since it has positive effects on the environment, the economy, and society.

Per household, 2.469 kg of food waste are created each week and end up in landfills, according to project data. In Cyprus, an estimated 47746.24 tons of residential food waste is generated each year. Commercial activity is thought to be responsible for an estimated 110504 tons of food waste annually.

There is a benefit of 131,555,001.14 kg CO2eq per year if food waste is used to produce biogas, mostly because renewable energy is produced and heavy fuel oil is not needed to produce power. 13,791,828.59 kWh of renewable electricity might be produced annually from food waste.

In total, it is estimated that 100,000 people were impacted by the program through its different channels. These residents' adoption of a "zero-waste" mentality might prevent the annual waste of 17,237 tons of food.

The results of the LIFE FOODPRINT project are crucial for designing and implementing policy related to food waste, GHG emissions mitigation, and sustainable resources management in Cyprus.

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Supplementary material

Figure S1. Reasons for buying more food than needed.

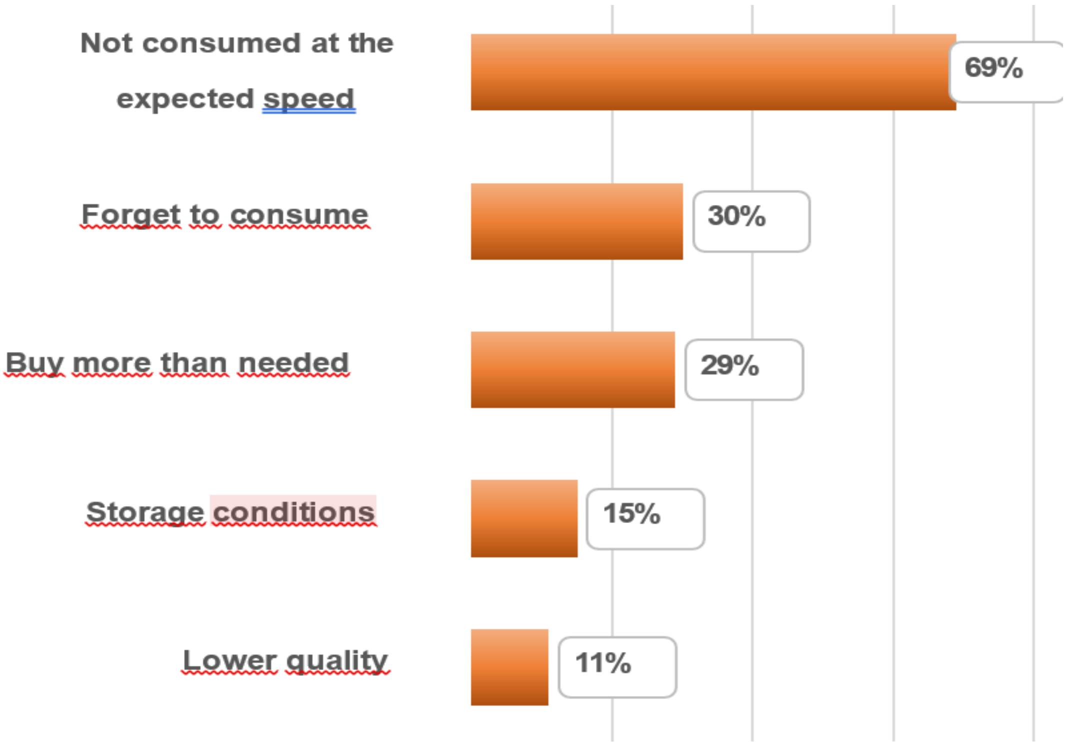

Figure S2. Reasons for generating food waste.

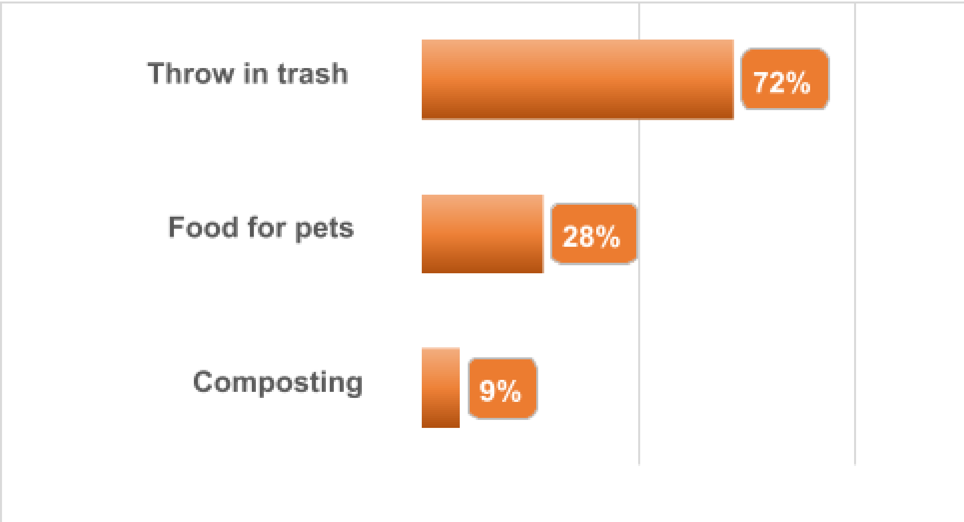

Figure S3. Managing food leftovers/food waste.

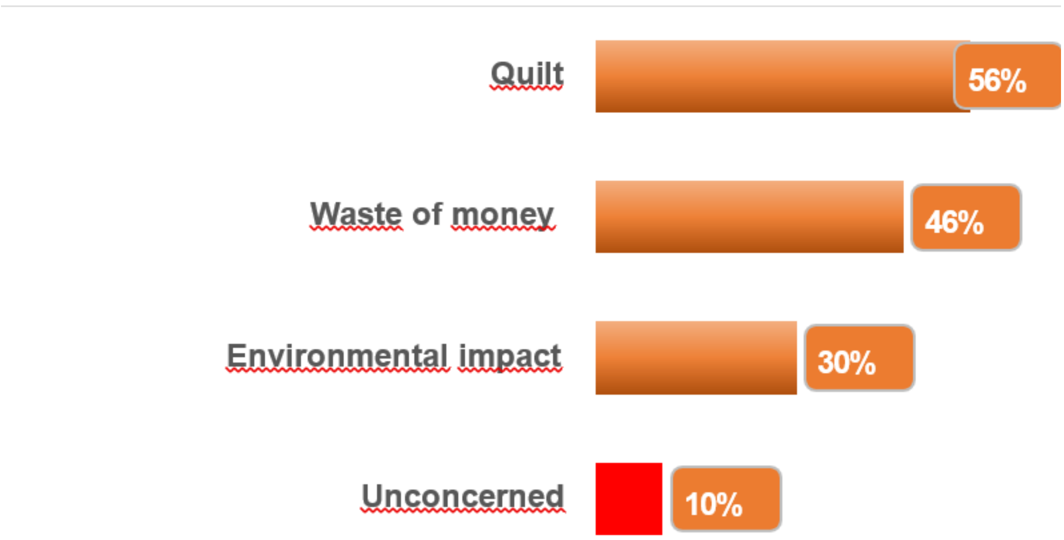

Figure S4. Feelings when food is wasted

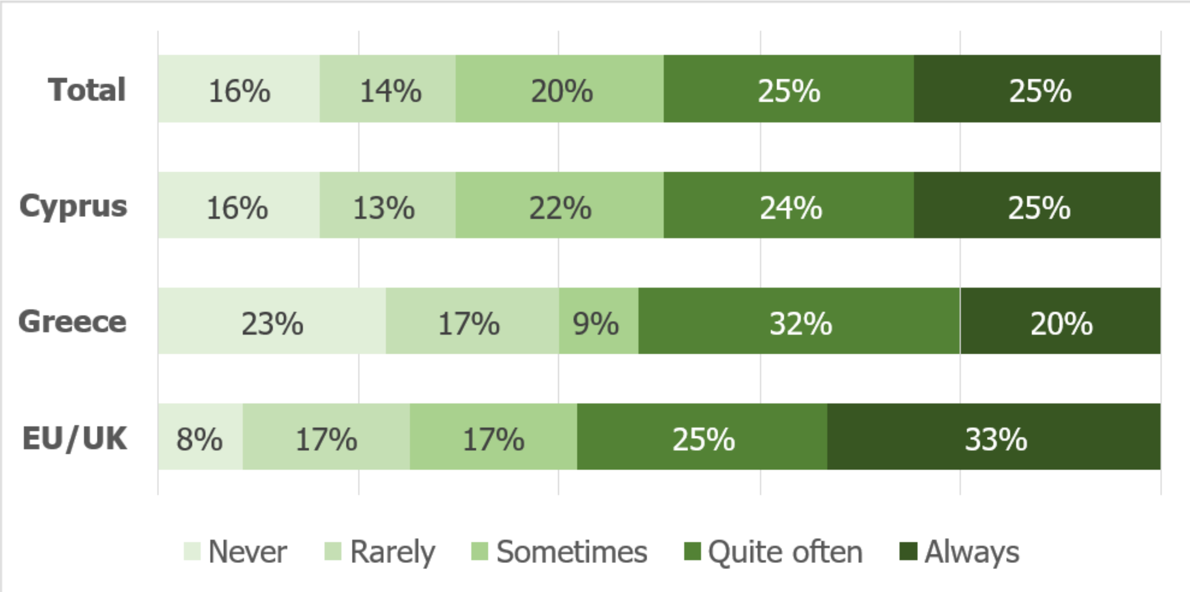

Figure S5. Taking food leftovers from restaurants

Annex

I. Questionnaire (food purchase)

Αισθάνεστε ενημερωμένος/η για το πρόβλημα της σπατάλης τροφίμων;

Α. Καθόλου

Β. Λίγο

Γ. Μέτρια

Δ. Πολύ

Πόσο σημαντικό περιβαλλοντικό πρόβλημα θεωρείτε τη σπατάλη τροφίμων;

Α. Καθόλου

Β. Περιορισμένης σημασίας

Γ. Μέτριας σημασίας

Δ. Μεγάλης σημασίας

Για τα ψώνια της εβδομάδας, γνωρίζετε εκ των προτέρων τα τρόφιμα που θέλετε να αγοράσετε;

Α. Ποτέ

Β. Σπάνια

Γ. Συχνά

Δ. Πάντα

Για τα ψώνια της εβδομάδας, αγοράζετε τρόφιμα τα οποία δεν έχετε συμπεριλάβει στον κατάλογο αγορών σας;

Α. Ποτέ

Β. Σπάνια

Γ. Συχνά

Δ. Πάντα

Πριν αγοράσετε ένα τρόφιμο, ελέγχετε την ημερομηνία λήξης του;

Α. Ποτέ

B. Σπάνια

Γ. Συχνά

Δ. Πάντα

<u>Ποια από τα παρακάτω τρόφιμα πετάτε συχνότερα (πολλαπλές απαντήσεις):</u>

A. Γαλακτοκομικά

B. Φρούτα ή λαχανικά

Γ. Κρέας ή ψάρια/ψαρικά

Δ. Είδη αρτοποιείου

E. Ζυμαρικά/όσπρια/ξηρά τροφή

Z. Αναψυκτικά/χυμοί/ποτά μακράς διάρκειας

H. Άλλο

Θ. Δεν πετάω τρόφιμα

<u>Πόσο συχνά πετάτε κάποιο προϊόν που αγοράσατε χωρίς να είναι στη λίστα αγορών σας;</u>

A. Ποτέ

B. Μερικές φορές

Γ. Συχνά

Δ. Κάθε εβδομάδα

<u>Ακολουθείτε τρόπους μείωσης της σπατάλης τροφίμων (π.χ. προσοχή στις ποσότητες, ημερομηνίες λήξης, κτλ.);</u>

A. Ναι

B. Όχι

<u>Πόσα τρόφιμα (φρέσκα, ληγμένα, χαλασμένα, μαγειρεμένα, κτλ.) υπολογίζετε ότι καταλήγουν στα σκουπίδια εβδομαδιαία από το νοικοκυριό σας;</u>

A. 0 kg

B. 1-2 kg

Γ. 2,5-5 kg

Δ. > 5 kg

Τι πιστεύετε ότι θα σας βοηθούσε να μειώσετε τη σπατάλη τροφίμων;

Α. Να γνωρίζω πόσα χρήματα μπορώ να εξοικονομήσω

Β. Να γνωρίζω πόσο επιβαρύνω το περιβάλλον

Γ. Να μάθω έξυπνους τρόπους ή εύκολες συνταγές αξιοποίησης προϊόντων που πρόκειται να λήξουν ή έχουν μαγειρευτεί ήδη μία φορά

Δ. Τίποτα από τα παραπάνω

Ποιος πιστεύετε ότι είναι ο τομέας που πρέπει να είναι πιο δραστήριος σε ό,τι έχει να κάνει με την αντιμετώπιση της σπατάλης τροφίμων;

Α. Επιχειρήσεις φιλοξενίας και εστίασης

Β. Νοικοκυριά/καταναλωτές

Γ. Κυβέρνηση/τοπικοί φορείς

Δ. Όλα τα παραπάνω

Έχετε κάποια εισήγηση σχετικά με τη σπατάλη τροφίμων και τους τρόπους αντιμετώπισής της;