Urban Shift for green innovations

FOOD WASTE

January 2023

Multicriteria

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Contents

Foreword

Urban Shift (UShift) is an experimental, impact-based, and transdisciplinary education programme that focuses on creating lasting change by bringing together students from Higher Education Institutions (HEI), a Vocational Education Institution (VET), urban experts, and business partners. This is to be achieved by combining intersectional environmental education, knowledge exchange, transdisciplinary collaboration, and sustainable innovation.

By providing the learners with the necessary GREEN LABOUR MARKET SKILLS (digital, green, business and transdisciplinary/resilient skills), UShift is creating a LIVING ECOSYSTEM for 80 learners from diverse backgrounds (urban design, environmental engineering, media and business) that fosters the development of solutions to pressing urban challenges. The learners, divided into two batches, will create 10 startup teams working on urban challenges linked to urban heat islands (UHI)/cooling, and food waste/circularity, or climate/extreme weather predictability and mobility/circularity. Thus, the project allows students to successfully transform into change makers and EU GREEN DEAL AMBASSADORS by equipping them with the knowledge and experience needed to become green entrepreneurs and/or future employees of green jobs on the global market.

The culmination of this education programme are two sets of LIVING EXHIBITIONS (8 separate exhibitions) spread across Barcelona, Genoa, Copenhagen, Stuttgart, and Vienna. Their purpose is to showcase the solutions and success stories that flourished from the UShift project lifetime in order to raise public awareness for humanity's biggest challenges (i.e., pressure on planetary boundaries, resource scarcity, persistent poverty, social injustice, exponential population growth, urbanization boom, global pandemics, etc.) and interest in the UShift LIVING LABS curricula, the European Green Deal, and the United Nations (UN) Sustainable Development Goals (SDGs). This will be done through an interactive exhibition programme made up of panel and roundtable discussions, media discourse, artistic events, workshops and knowledge exchange via the exhibition of the developed courses and start-up prototypes. The goal is to inspire individual stakeholders such as NGOs, consumers, green start-ups, policy makers, and incubators to take part in the global Urban Shift as active change makers.

Even after the project's lifetime, UShift will continue to have a positive impact via the establishment of an easily adaptable LIVING CURRICULUM template and OPEN ONLINE TRAINING sessions that will be made available on YouTube to inspire future transdisciplinary collaboration. Furthermore, the establishment of an ALUMNI NETWORK serves as a tool to foster sustainable project outputs and the continuation of the start-up teams, as well as serves as a channel for peer-to-peer learning, support, knowledge and expertise exchange, collaboration, co-creation, and mentorship between the learners, start-up teams, business partners and urban expert during and after the project.

Urban Shift is a project developed by Wirtschaftsuniversitat Wien - WU (Austria), Institute for Advanced Architecture of Catalonia - IAAC (Spain), Hochschule Der Medien - HdM, (Germany), Wirtschaftskammer Österreich - WIFI (Austria), Multicriteria- MCRIT (Spain), Terra Institute - TERRA (Italy), Pretty Ugly Duckling - PUD (Denmark), Green Innovation Group A/S - GIG, (Denmark), and co-funded by the Erasmus+ Key Action 2 Partnerships For Innovation Alliances For Innovation 2021 Programme of the European Union.

Background

Over the past two decades the predictability of food production experienced during the second half of the twentieth century has been becoming less certain. Climate change, population growth, environmental degradation and consumption patterns are just some of the issues driving continual change within the system.

The way we produce food today is a significant driver of both climate change and biodiversity loss. It relies upon ever-increasing quantities of synthetic fertilisers, pesticides, fossil fuels, fresh water, and other finite resources. These are a source of pollution and damage to ecosystems and human health. The heavy use of antibiotics in farming is also linked to disease-causing microorganisms becoming resistant to medications.

The problems in food consumption transcend food waste, as over half of the adult population in Europe are overweight, and nearly 33 million people in Europe cannot afford a quality meal every second day (Eurostat 2021). These figures reveal the relevant impact of food waste on the health of our planet and its inhabitants. They also show a pressing need to prevent and reduce food waste to make the transition to a resource efficient Europe.

Food Waste and Loss History

Our present is a product of the past. Conservation techniques, consumerism, capitalism, world exploration and the everlasting quest for growth come forward throughout food waste's history, but *how did humans come to create a yearly food loss phenomenon of ~2.5 billion tons per year (⅓ of all food produced)*[1]*?*

Historical research shows that humans around the Dead Sea of Jordan were the first in the world to develop systematic large-scale food storage, around the year 12.000 BC. 2000 years later, the Neolithic Revolution implied the transition from hunter-gatherer to agricultural activities: the crops yielded surpluses that needed storage.

In the beginning of the 17th century, agricultural innovations accelerated food production, which originated the first documented structural food surpluses. Farmers were no longer bound to local markets which freed them from lowering their prices or even discarding produce.

With the industrial revolution (1900) food cost even less and was more easily available, so it was more easily wasted. With lack of waste removal, diseases were easily spread in large cities and then the food waste disposal was addressed as a health problem: the first garbage delivery wagons date from the late XIX century. On the other side, other means of conservation were invented such as cans, widely used in wars.

The conservation problem was common for meat, vegetables, fruits until the 1930s when the mass production of home refrigerators started, alongside refrigerated storages and means of distribution (such as train wagons). Food waste reduced as leftovers could be stored longer.

During the second half of last century, agriculture was achieving ever higher levels of production. The main explanations are the relentless technological updates and farmers'

[1] Global Food waste in 2022 https://www.greenly.earth/en-us/blog/ecology-news/global-food-waste-in-2022

extreme specialisation that has its origins on international trade. This has clear consequences for the environment. By the end of last century, the first environmental movements started alerting on the implications of global warming, but there was a lack of knowledge about food or food waste implication on that problem.

The Food and Agriculture Organisation of the United Nations, created after WWII, has amongst their main goals they have the incision in food systems; reducing food waste, boosting sustainability, inclusion and efficiency and tackling health issues related to food.

Is food loss the same as food waste?

The two terms are related but distinct. Food waste, according to the Food and Agriculture Organization (FAO) of the United Nations, is "the discard of edible foods at the retail and consumer levels." In other words, food waste happens downstream, during either the distribution stage (for example, as food makes its way from a retailer's warehouse to a store shelf) or the consumption stage (such as people throwing out leftovers). Food loss, on the other hand, happens upstream: the FAO defines it as "the decrease in edible food mass at the production, post-harvest, and processing stages of the food chain."

"Food waste occurs at retail and households, unlike food lost, that occurs along the food supply chain up to, but not including, the retail level. This definition excludes food destined to other economic uses (such as animal feeding) and inedible parts of the food" (FAO)

However there is a broader definition[2], which defines food waste as any food removed from the food supply chain to be recovered or disposed of. It includes food wasted at any single level of the production process and also inedible parts of food (skin or bones). The aim beyond this broad definition is to support the development of resource efficient and sustainable food systems in the EU.

Regulatory bodies and industry groups alike have taken steps to address both food waste and food loss. In fact, the United Nations' Sustainable Development Goal 12, which focuses on ensuring sustainable consumption and production patterns, includes target 12.3 to "halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains" by 2030. Meeting this goal would cause a 38% reduction in the carbon footprint of food loss and waste, equivalent to the GHG emissions of Japan.

KEY IDEAS

- There are a wide range of challenges in our food systems: a growing population, growing competition and scarcity of land, water and energy for food production, overconsumption, food waste and climate change among others.
- Food waste means discard of edible foods at the retail and consumer levels, while food loss is the decrease in edible food mass at the production, post-harvest, and

[2] Fusions EU http://www.eu-fusions.org/

processing stages.
- Food waste is more common in contexts of resource abundance and to poor conservation methods.
- Food waste implies the waste of economic and natural resources

How food waste affect the food system?

Food waste is an issue that affects all aspects of the food system, a complex web of activities involving the production, processing, transport, and consumption.

Food systems account for over one-third of global CO_2 emissions, considering the way we produce, process, package, transport, and consume food (UN, 2021). In the EU, eighty-eight million tonnes of food waste are generated each year with associated costs estimated at €143 billion and around 20% of produced food is lost or wasted. Moreover, considering the food wasted in homes, restaurants, and shops, and the food lost on farms and in supply chains, a third of the total food produced in the world is never eaten, with 8-10% of global CO_2 emissions associated with unconsumed food (UNEP, 2021).

Fig. 01: Our Food System Source: https://www.food.systems/

Our current linear model, also known as the "make, use, and dispose" model, is based on the idea that resources are extracted, used to create a product, and then discarded once the product is no longer needed. This model is inefficient, wasteful, and unsustainable for several reasons:

- Waste: The linear model generates a lot of waste, as products are designed for single use and are disposed of once they are no longer needed. This waste often ends up in landfills, where it takes up space and can have negative environmental impacts.

- Resource depletion: The linear model relies on the extraction of new resources to create products, which can lead to the depletion of finite resources and contribute to environmental degradation.
- Inefficiency: The linear model is inefficient, as it does not take into account the value of the materials and resources that go into a product once it has been used. This results in the loss of valuable materials that could be used again.

We need to move from this to a circular food system where we use resources more efficiently and re-use side and waste streams. The circular model is based on the principles of sustainability and seeks to keep resources in use for as long as possible, extract the maximum value from them while in use, and then recover and regenerate products and materials at the end of their useful lives. This model is more efficient, less wasteful, and more sustainable than the linear model, as it seeks to minimize waste, reduce resource depletion, and make the most efficient use of resources.

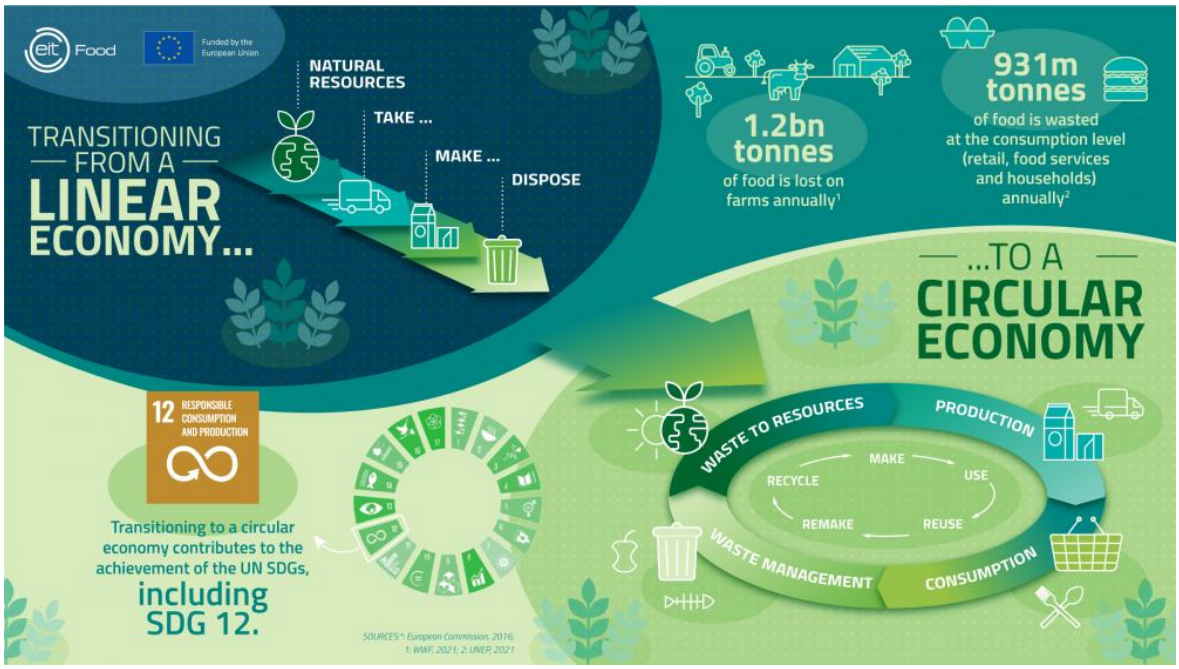


Fig. 02: From linear to circular economy. Source: https://www.eitfood.eu

Effects: Why do we care about Food Waste?

First of all, the fact that food waste exists means that there have been used more resources than the ones needed for alimentation purposes, and at the same time, more waste has been generated. It happens that food is not equally distributed, meaning that while in some contexts food is being wasted, in some others, that could be a few metres apart, people are starving. Having this in mind, the effects of food waste can be divided into:

Human Health

One of the global active challenges is feeding: the United Nations Food and Agriculture Organisation (FAO) estimates that about 815 million people (10.7% of world's population), were suffering from chronic undernourishment in 2016. At the same time, one-third of all the food produced in the world goes to waste.

Air Quality and Greenhouse Gases

Wasting food is not only an ethical and economic issue but it also depletes the environment of limited natural resources. When food goes to the landfill and rots, it produces methane—a greenhouse gas even more potent than carbon dioxide. According to FAO, food waste has a global carbon footprint of about 7% of all global greenhouse gas (GHG) emissions caused by humans. At the same time, trees that produce the oxygen we breathe are being cut down in favour of land to grow or dispose of food.

Water Quality

According to the World Resources Institute, an environmental think tank, inside the 1.3 billion tons of food wasted every year worldwide, there are over 170 trillion (1012) litres of water. This represents a waste of 24% of all water used for agriculture, already being the sector that consumes more water worldwide (around 70% of freshwater withdrawals).

Fruits and vegetables are the largest source of water loss and waste, mainly as a result of extremely high wastage levels (over 50%). Even despite the water cycle, the water-stressed regions that produce fruits and vegetables aren't necessarily going to get their water back (NPR, 2013). Also some of the water will be retained and poured in dumps. Intensive animal feeding operations, with big quantities of animal waste can infiltrate water and make it pollute.

Habitat destruction

Food waste can contribute to habitat destruction through the use of land, water, and other resources that are required to produce food. For example, the production of livestock requires large amounts of land and water, and the expansion of livestock production can lead to deforestation and the destruction of natural habitats. In addition, the use of pesticides and fertilizers in food production can contaminate soil and water, and can harm wildlife and other forms of biodiversity.

Biodiversity

The vast majority of wasted food is fruits and vegetables, and this wastage attracts wildlife, which can be harmed by these decaying foods. Litter can also draw large wildlife such as brown bears, wolves or wild boar, feeding them and approaching them to other species, ecosystems or even towns and cities.

Each ecosystem has its food chain, with its prey and predators. Large wastage of food can lead to increased numbers of one, which can then put the second in the chain out of balance. An example for this is fishery dumps, with over 7 billion tons of waste dumped into the ocean every year. This attracts seagulls, who feed on this fish, so easily getting feeded and reproduced. This exponential growth takes the ecosystem out of its natural balance.

Energy Use

Food systems consume about 30% of available global energy and out of this, 38% is utilised to produce food that is either lost or wasted (FAO, 2015). More than 70% of this energy is consumed on the transportation and distribution chain.

There is also an ethical dimension to food waste, as it involves the unnecessary use of resources and the waste of food that could be used to feed people in need.

KEY IDEAS

- Food Waste is a global challenge with consequences in many instances.
- The products containing a higher percentage of water are the ones more attached to waste (more water consumption and GHG emissions).
- Excessive wastage levels disrupt trophic chains and can poison soils and water.

Food Waste in Europe

Industrialised and higher-income countries see more food loss and waste relative to other countries. In most industrialised countries, approximately half of total food waste is incurred at the consumption stage of the value chain, by individuals. Food waste also has a huge environmental impact, accounting for 8-10% of global greenhouse gas emissions (UNEP Food Waste Index 2021) and about 6% of total EU greenhouse gas emissions (WWF). In the EU, households generate more than half of the total food waste (55%) in the EU with 71% of food waste arising at household, food service and retail (Eurostat, 2022). Around 88 million tonnes of food waste are generated annually in the EU alone, with associated costs estimated at €143 billion.

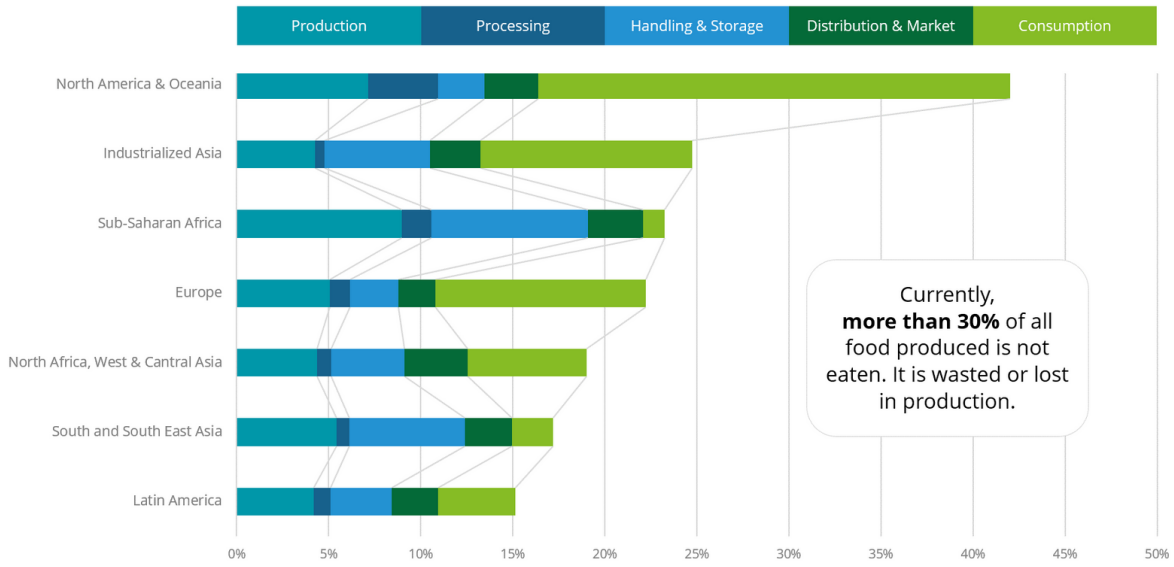


Fig. 03: Food waste and loss across the globe. Source: Deloitte https://bit.ly/3VdVQoH

In the European Union, 32,6 million people (7.3 % of the entire EU population) cannot afford a quality meal (including meat, chicken, fish or a vegetarian equivalent) every second day. The highest values are located in Bulgaria and Romania (above 19%) and the lowest in the Netherlands, Ireland and Cyprus, with shares lower than 2% (Eurostat, 2021).

Eurostat estimates that nearly 57 million tonnes of food waste (127 kg/inhabitant) are generated annually with an associated market value estimated at 130 billion euros. Around 10% of food made available to EU consumers (at retail, food services and households) may be wasted (Eurostat, 2022). As shown in the figure below, households are clearly the food chain stage where more food is wasted (55%), followed by the

processing stage (18%) and primary production (11%). Restaurants and food services account for the 9% and around the 7% of the share belongs to retail.

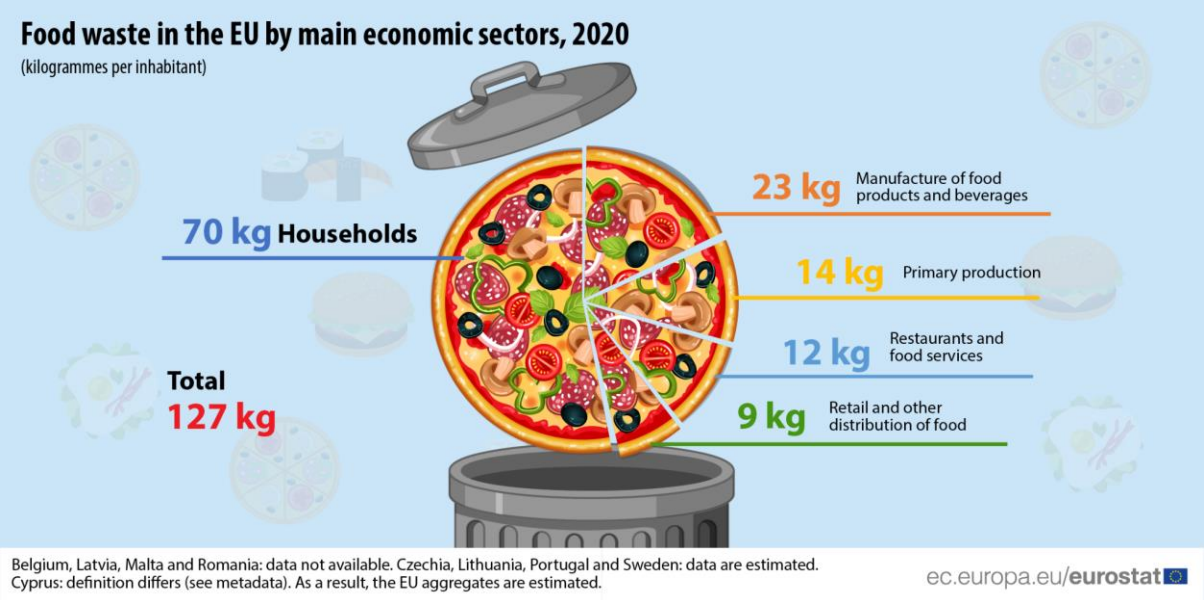


Fig. 04: Distribution of the Food Waste generated per inhabitant in Europe. Source: Eurostat.

Regarding the national distribution of food waste, Eurostat retrieves this data from 2020, with the first publication being made in October 2022. The countries with higher waste in kilos per inhabitant are Cyprus (397), Denmark, Greece and Portugal and at the end of the table there are Slovenia (68), Croatia and Slovakia.

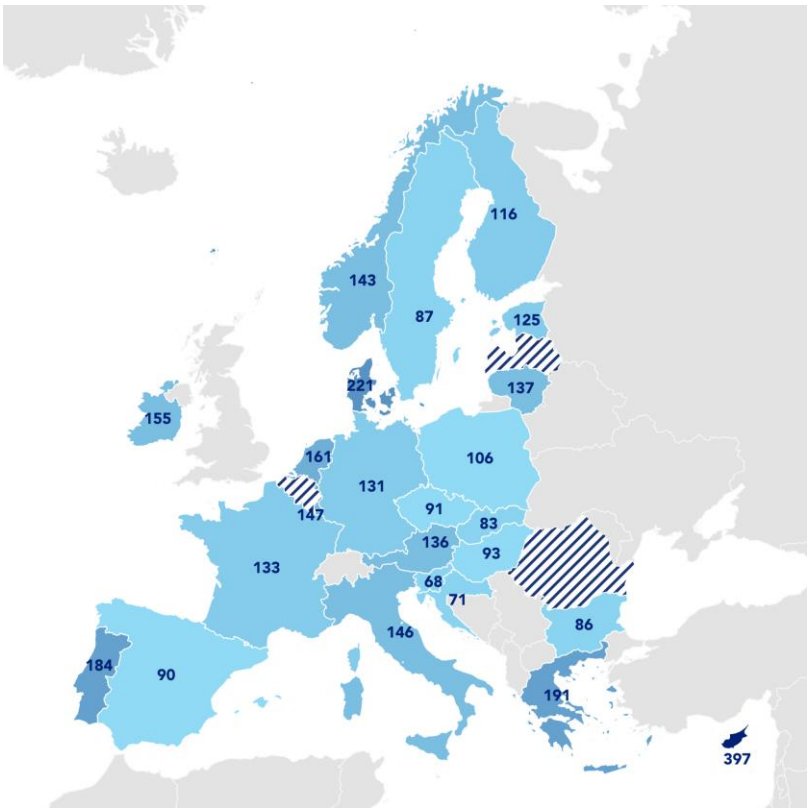


Fig. 05: Total food waste in kilos per inhabitant. 2020. Own creation. Source: Eurostat.

When it comes to a sectoral distribution, the following figure shows an unequal share amongst the member states. In Cyprus or Bulgaria, the greatest loss happens in primary production, in Portugal or Slovakia, the greatest share happens at Households and finally, Ireland and Cyprus have considerable shares of waste at a retail and food services level.

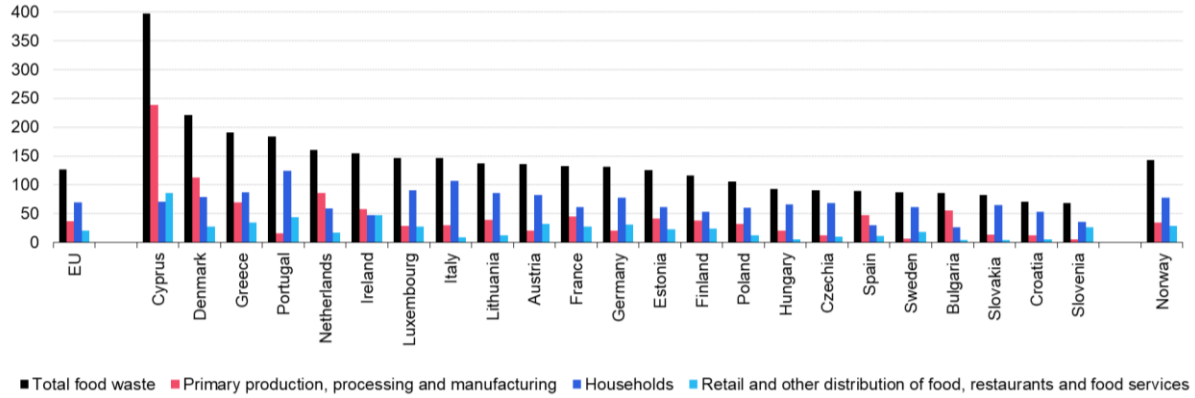


Fig. 06: Food waste by sector in kilos per inhabitant. 2020. Own creation. Source: Eurostat.

Tackling consumer food waste remains a challenge both in the EU and globally. Household food waste is nearly twice the amount of food waste arising from the sectors of primary production and manufacture of food products and beverages, in which strategies exist for reducing food waste, for instance with the use of discarded parts as by-products. Additionally, countries with a rather small population that are net exporters of raw and manufactured food products are showing high amounts of food waste, especially in the processing and manufacturing sector.

European Policies

The European Parliament has consistently fostered the reduction of food waste. Hereby there are different initiatives adopted by European institutions:

The EU Platform on Food Losses and Food Waste (FLW) was established in 2016, bringing together institutions, experts, international organisations and relevant stakeholders. This Platform aims to support all actors in: defining measures needed to prevent food waste; sharing best practice; and evaluating progress made over time.

In May 2018, the Waste Framework Directive was revised. It set some key requirements to tackle food waste that were already created or are expected to be during the next few years. The first of all is the establishment of a common methodology and quality requirements for the uniform measurement of food waste levels [link].

National prevention programmes, monitoring and implementation assessment were driven in a resolution of the European Parliament from January 2020 that calls for an EU-wide food waste reduction target of 50 % by 2030 based on a common methodology for measuring food waste. Member States are expected to report on national food waste levels from this year 2022 on.

As part of the European Green Deal action plan, the European Commission presented in May 2020 a 'Farm to Fork strategy' aimed at making food systems more sustainable. One of the targets included in the strategy is 'stepping up the fight against food waste', that is, cutting food waste by half with the help of legally binding EU-wide targets by 2023.

A Commission study published in 2018 estimated that 10% of food waste in the EU supply chain is linked to date marking. In this sense, there were introduced the 'best before' date (or 'date of minimum durability'), indicating the date until which the food retains its specific properties when properly stored, and the 'use by' date, indicating the last day on which the product is considered to be safe.

Member states have already taken steps to encourage food donation and other means of redistribution for human use and for the implementation of a waste hierarchy. Some examples are: reducing VAT rates for donated food, revising legislation promoting food donations and providing support to food banks and non-profit organisations that distribute donated food.

KEY IDEAS

- Food waste has different patterns all over the globe, affecting different stages of the food chain.
- In Europe more than half of the food is wasted at household level.
- The EU has set the 2030 deadline to reduce food waste by 50%.
- Both the European Green Deal action plan, and the 'Farm to Fork strategy' aim at making food systems more sustainable.

Case: Meat waste and its water footprint

Meat waste and food waste are closely related. Meat production is a particularly resource-intensive process, requiring significant amounts of land, water, and energy to raise and process animals. In addition, the production of meat is also a major contributor to greenhouse gas emissions, which contribute to climate change. As a result, meat waste can have significant environmental impacts.

Meat waste occurs at various stages of the food supply chain: in the production stage, a significant amount of waste is generated by culling and sorting animals, as well as by mortalities. In the processing stage, waste can be generated by trimming and processing meat cuts. In the distribution stage, waste is provided from spoilage and damage to meat products during transportation. At the retail level, waste can be generated by overstocking and stock rotation, and at the consumer level, waste can be generated by purchasing too much meat and not using it before it spoils.

The water footprint of meat production refers to the amount of water used to produce a given amount of meat. This varies depending on the type of animal and the production system. Beef production, for example, has a higher water footprint than pork or chicken production because it takes more water to produce feed for cows than for pigs or chickens. Additionally, intensive production systems, such as feedlots, have a higher water footprint than extensive systems, such as grass-fed beef. The water footprint of meat production can be reduced by improving the efficiency of water use in feed production, using more sustainable production methods, such as regenerative agriculture, and reducing meat consumption.

Meat waste is also closely related to food waste, as both issues are driven by similar factors, such as overproduction, overconsumption, and poor distribution and storage

practices. In addition, the consumption of meat is a major contributor to food waste, as a large proportion of the food produced globally is used to feed animals raised for meat, rather than being directly consumed by humans. Efforts to reduce meat waste and food waste mostly relate to the reduction of meat consumption and the adoption of more sustainable consumption patterns.

Meat production framed in a circular economy includes sustainable and regenerative production methods, closed-loop systems, and the recovery and reuse of by-products. In this approach, the waste generated in the production of meat such as animal waste, bones, blood, and fat are seen as valuable resources that can be recycled and reused in other industries, instead of being discarded as waste. This can reduce the environmental impact of meat production, increase the efficiency of resource use, and create economic benefits through the creation of new revenue streams. This approach also considers fair labour practices, animal welfare and local sourcing to build resilient and sustainable communities.

Circular Economy for Food

As mentioned before, circular economy is a regenerative approach to a system capable of generating value and prosperity enlarging products' useful life and returning residues from the back to the start of the supply chain.

It is an economic model that aims to avoid waste and to preserve the value of resources (raw materials, energy and water) for as long as possible. The circular economy is based on three principles:

- Eliminate waste and pollution
  Currently, our economy works in a take-make-waste system. We take raw materials from the Earth, we make products from them, and eventually we throw them away as waste. Much of this waste ends up in landfills or incinerators and is lost. This system cannot work in the long term because the resources on our planet are finite.

- Circulate products and materials (at their highest value)
  This means keeping materials in use, either as a product or, when that can no longer be used, as components or raw materials. This way, nothing becomes waste and the intrinsic value of products and materials is retained. There are a number of ways products and materials can be kept in circulation and it is helpful to think about two fundamental cycles – the technical cycle and the biological cycle.

  In the technical cycle, products are reused, repaired, remanufactured, and recycled. In the biological cycle, biodegradable materials are returned to the earth through processes like composting and anaerobic digestion

- Regenerate nature
  By shifting our economy from linear to circular, we shift the focus from extraction to regeneration. Instead of continuously degrading nature, we build natural capital. We employ farming practices that allow nature to rebuild soils and increase biodiversity, and return biological materials to the earth. Currently, most of these

materials are lost after use and the land used to grow them is depleted of nutrients.

A circular economy for food mimics natural systems of regeneration so that waste does not exist, but is instead feedstock for another cycle.

In a circular economy, organic resources such as those from food by-products, are free from contaminants and can safely be returned to the soil in the form of organic fertiliser. Some of these by-products can provide additional value before this happens by creating new food products, fabrics for the fashion industry, or as sources of bioenergy. These cycles regenerate living systems, such as soil, which provide renewable resources, and support biodiversity.

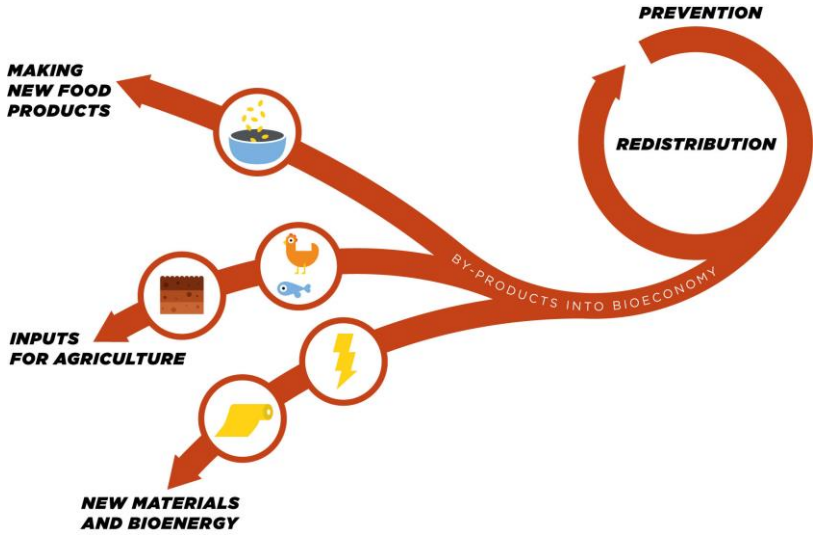


Fig. 07: Source: https://ellenmacarthurfoundation.org/

The goal of applying a circular economy approach to food waste is to decouple economic activity from the consumption of finite resources and create a resilient system that is good for business, people and the environment.

How to build a better food system?

There are many ways to build a better food system, and the specific approach will depend on the resources and goals of the community or organization. Some potential strategies include:

- **Eliminate food waste**

  Eliminating food waste is a step forward on solving other existing problems such as improving food security and nutrition, reducing greenhouse gas emissions, lowering pressure on water and land resources and increasing productivity and economic growth (Food and Agriculture Organisation, 2019). It also saves food for human consumption; brings savings for primary producers, companies and consumers; and lowers the environmental and climate impact of food production and consumption (European Commission, 2021). Eliminating or reducing food waste is an important way to improve the food system. This can be done through

education, better storage and transportation infrastructure, and changes to food labeling and expiration dates.

- **Ensure a regenerative food production**
  Growing food while generating positive outcomes for nature such as healthy and stable soils, and improved local biodiversity, air or water quality is known as regenerative food production. There are practices in local contexts such as using diverse crop varieties and cover crops, rotational grazing, and agroforestry that result in agricultural land that provides a habitat for a wide range of organisms. Allowing roots and stubble from harvested plants to break down on the land or reusing organic waste flows to create organic fertilisers are other examples of that. This results in agricultural land that more closely resembles natural ecosystems such as forests that provide habitat for a wide range of organisms.

Fig. 08: Source: https://ellenmacarthurfoundation.org/

And after the production stage, the challenge against food waste persists. There are measures such as the redistribution of food surplus to people who may need it and the reuse of inedible food and human waste as a base for new products.

- **Consume locally produced food**
  More than 40% of the world's irrigated cropland is located in peri-urban areas, yet the food produced on this land is often flown to consumers on the other side of the world while similar products are imported into neighbouring cities. By reconnecting towns and cities with local food production and balancing this with global supply, resilience can be built into the food supply chain.

Fig. 09: Source: https://ellenmacarthurfoundation.org/

On a smaller scale it supports local communities: by connecting people with local food production, smallholder farms can be preserved, benefitting both their communities and the environment. Additionally, smallholders use less resources and land, compared to large corporations and have the added benefit that green belts around the city contribute to cleaner air. Urban-rural relationships like this are increasingly being seen as a priority to build resilience into communities of all sizes.

Finally, it can report economic benefits first of all with the savings in transportation; second by using organic waste streams, which contain high levels of nitrogen and phosphorus; and third by using organic fertilisers instead of chemical alternatives (direct savings plus additional medical benefits).

- **Advocate for policy change**

  Governments can play a role in shaping the food system through policies and regulations. Advocacy efforts can help to bring about changes that support a more sustainable and equitable food system.

KEY IDEAS

- The circular economy is an economic model that aims to reduce waste and promote the continuous use of resources.
- The circular economy is based on three principles: Eliminate waste and pollution; Circulate products and materials (at their highest value); Regenerate nature
- Food waste can be converted into food inputs for agriculture and new materials.
- The elimination of food waste improves food security and nutrition.
- A resilient supply-chain relies on food locally grown.

Cities as Catalysts for Change

Cities and food are inextricably linked. Ever since their genesis they are interconnected on the levels of production, processing, logistics and of course consumption. Today more than half of the global population lives in urban areas, this means that the choices made in cities can have a major impact on the food system.

Fig. 10: Source: https://ellenmacarthurfoundation.org/

Cities, and everyone within them, have a unique opportunity to spark a transformation towards a circular economy for food. Half of the world's population currently lives in cities. This number is expected to grow to 68% by 2050 at which stage 80% of the world's food will be eaten within cities.

In cities, consumption of food per person tends to be greater due to urban citizens earning higher average incomes than rural citizens. Yet, the high proportion of the food that flows into cities is processed or consumed in a way that creates organic waste in the form of discarded food, by-products or sewage.

The close proximity of citizens, retailers, and service providers (40% of cropland is within 20km of cities), makes new business models possible. Demand power, due to the sheer volumes of food eaten, means that city businesses and governments are ideally placed to influence the type of food that enters a city, and how and where it is produced.

Cities have the potential to create a more efficient and sustainable food system by rethinking the concept of food waste. Instead of viewing food waste as a byproduct to be disposed of, cities can adopt a circular approach that seeks to maximize the value of all food products. This can involve initiatives such as transforming food byproducts into new products, such as organic fertilizers and biomaterials, or using them as feedstocks for bioenergy. By doing so, cities can generate new revenue streams and help to design out the concept of waste altogether. As the main destination for much of the food produced, cities have a unique opportunity to lead the way in creating a more circular and sustainable food system.

KEY IDEAS

- 50% (and increasing) of the world's population is living in cities.
- In cities there is more food consumption and higher waste generation.
- Cities have the potential to become crucial in food waste transformation.

Design for Food

Historical Trends in Food and Conventional Architecture

Food architecture trends often follow similar patterns as those in traditional architecture because they both reflect the current trends and values of society. For example, during the mid-20th century, there was a trend towards brutalist concrete structures, especially tower blocks, shopping centres, and university buildings. At the same time, there was a proliferation of brutalist processed foods, such as TV dinners, sliced bread, meat spreads, and powdered drinks. These trends were driven by a focus on affordability and practicality, but they also resulted in a loss of connection to nature and traditional methods of food production.

Fig. 11: Brutalist building and brutalist processed food

At the end of the 20th century, architects inspired by postmodernism created unique buildings that defied our expectations of form and function. Around the same time, food architects inspired by molecular gastronomy created edible structures that challenged our expectations by using unusual ingredients or processes. These exquisite buildings and foods may have reflected deeper changes in society where a new class of affluent individuals were trying to distinguish themselves from the past. It is interesting that the swirling forms of post-modern architecture and the creamy emulsions and airy foams of molecular gastronomy both flourished in a period of conspicuous consumption as the financial markets frothed.

Fig. 12: End of 20th century examples of exquisite buildings and foods

The global economic recession in 2008 had an impact on both food and architecture, as there was a shift towards more sustainable, locally-sourced, and organic products in both areas. Architects began to use more locally-sourced, organic materials in their buildings, while chefs focused on using local and organic ingredients in their dishes. Urban planners also started designing compact, walkable neighborhoods that encouraged people to purchase smaller amounts of food at a time, which helped to reduce waste. These changes reflected a broader cultural trend towards sustainability and authenticity.

Fig. 13: Early 21th century changes towards more sustainable, locally-sourced, and organic products

Circular Food design

In a circular economy, food products are designed to be healthy, right through from production to nutrition. New innovations, products and recipes can play their part in

designing out of waste. Marketing can position delicious and healthy products as easy and accessible choices for people on a daily basis. Food brands, retailers, restaurants, schools, hospitals, and other providers can guide our food preferences and habits to support regenerative food systems.

Food designers can use the principles of the circular economy and apply them across all dimensions of food design, **from product concept, through ingredient selection and sourcing, to packaging**.

Regenerative design

Designing products with the goal of promoting and supporting the natural environment, and setting targets for positive impacts on nature in the design process, can encourage product development teams to create items that have a positive and regenerative impact on the environment.

Ingredient selection and sourcing

Focus on achieving the best outcomes by taking into account which ingredients are included in formulations, how they are produced, and importantly, what role they play in regenerating the landscapes they are produced in.

Packaging

Three strategies can be used to help businesses achieve their circular economy goals for packaging: elimination, reuse, and material circulation.

Fig. 14: Source: Circular design for food, Ellen MacArthur Foundation, https://bit.ly/3jhEt8m

KEY IDEAS

- Our current food system conceptually still relates to the brutalist movement.
- Food is cheap and functional but with high environmental costs.
- In parallel, tendencies to real food and organic meals relate to sustainable building and neighborhoods.

Strategies to Reduce Food Waste

Many industrialized countries are implementing strategies to reduce food waste. These strategies may involve the use of new technologies to improve food storage and transportation; education campaigns to increase public awareness of food waste and how to reduce it; and policy changes that are led by institutions. These efforts can help to create a more sustainable and efficient food system. There are several trends in food waste reduction that are worth noting:

Increasing awareness

There is growing awareness of the problem of food waste, and more people are taking steps to reduce their own food waste. Here some examples of raising food waste awareness:

- Educational campaigns: Governments and non-profit organizations can create educational campaigns to teach people about the impact of food waste and how to reduce it. These campaigns can include information on how to store and prepare food to reduce waste, as well as the environmental and economic consequences of food waste.

- Social media campaigns: Social media platforms can be used to raise awareness about food waste and share tips and resources for reducing it.

- Labelling and marketing: Businesses can use labelling and marketing to communicate the environmental and social benefits of reducing food waste. For example, they can label products as being made with "ugly" produce (i.e. produce that may not meet traditional cosmetic standards but is still perfectly edible) to highlight the importance of reducing food waste.

- Community events: Governments and non-profits can host community events, such as food waste festivals or waste-free potlucks, to raise awareness about food waste and encourage people to take action.

- Partnerships with schools and universities: Governments and non-profits can partner with schools and universities to teach students about food waste and how to reduce it. This can be done through educational programs, field trips, and other activities.

Government action

Many governments around the world are taking action to reduce food waste, such as:

- Implementing food waste reduction targets: Many governments have set targets to reduce food waste, such as the European Union's goal of halving food waste by 2030.

- Developing food waste reduction regulations: Governments can implement regulations that require businesses, such as grocery stores and restaurants, to reduce food waste. For example, France passed a law in 2016 that prohibited supermarkets from throwing away or destroying unsold food, and required them to donate it to charities or for animal feed.

- Funding food waste reduction initiatives: Governments can provide funding for initiatives that aim to reduce food waste, such as research into food waste prevention technologies or educational campaigns to raise awareness about the issue.

- Promoting composting: Governments can encourage the use of composting as a way to reduce food waste and improve soil health. This can be done through funding for composting infrastructure, education campaigns, and regulations that require businesses to compost food waste.

- Encouraging the use of surplus food: Governments can support initiatives that redistribute surplus food to those in need, such as food banks and soup kitchens. This helps to ensure that food that would otherwise go to waste is put to good use.

Business action

Many businesses, particularly in the food and hospitality sectors, are taking steps to reduce food waste, such as:

- Implementing "first in, first out" systems to ensure that older products are used before they expire

- Applying portion control: Many restaurants serve large portions that can lead to excess food being thrown away. By implementing portion control, businesses can reduce the amount of food they serve and reduce waste.

- Donating excess food: Many businesses, especially restaurants and grocery stores, have programs in place to donate excess food to charities or food banks. This helps to ensure that food that would otherwise go to waste is put to good use.

- Composting: Many businesses, especially restaurants, generate large amounts of food waste that can be composted. Composting food waste helps to reduce waste and can also provide a source of organic matter for use in gardening and agriculture.

- Reducing packaging: Packaging can contribute to food waste by making it more difficult to store and transport food. Businesses can reduce packaging by using reusable containers or biodegradable materials.

- Using technology to improve supply chain management: Businesses can use technology, such as forecasting software and real-time data analysis, to improve their supply chain management and reduce waste by ensuring that food is produced and distributed in a more efficient and sustainable way.

Technology

The food-tech industry is one of the most developed sectors in the start-up world. Deeply immersed in the fourth industrial revolution, it has room to grow in fields such as bio-innovation, genetic editing, robotics, big data, artificial intelligence and machine learning.

Despite the pandemic, it experienced a 42% growth during 2020, something directly related to changes in consumer preferences. Since this is a sector in constant development, there are still new challenges for companies and start-ups in the industry, which must adapt to the trends of a market that is increasingly aware of the practices behind food production. As the industry grows, new technologies are emerging, bringing with them the development of key solutions and trends to enhance sustainability in the food industry:

- Food safety insight: Improving freshness tracking from farm to store by using sensors and machine-learning algorithms would provide stakeholders information on what to do to ensure freshness and prolong food life. It can improve their decisions about where food can be routed, when it should be displayed, and what the appropriate shelf life of a product is. Exponential increases in biological information contained in gene and protein databases will continue, using biosensors and diagnostics, to enhance productivity. Another approach is automating the interpretation of consumer feedback, achieving an early detection of potential food health issues, and preventing food loss.
- Food waste insight: A key challenge is to identify what is thrown out, how much, and where this food originates. Smart solutions are used in restaurants to identify wasted food, the menu items to which they relate and deduce why those are being thrown out. After the use of these technologies, the food services are able to more precisely predict food consumption and hereby cut down their food waste.
- Supply chain traceability: Many people demand more information about the food they're eating. The combination of interest in information and technological advancements will result in increasing traceability and sophisticated, multiple product channels from farm to shelf. Giving the final customers transparency in the safety and precedence of their food will result in less waste. Accordingly, blockchain technology is being used to digitally audit products, even in real time, with its databases that track all the processes, with information such as an ID, location, timestamp… allowing traceability.
- Make food for the future: New drying technologies are being developed in order to conserve produce (excess and discarded food) while conserving most of its nutritional value and extending its lifespan from some weeks up to 25 years. This technology eases conservation, reduces weight and volume and consequently

pollution generated in transportation and storage. The next steps in this industry is to improve the energy efficiency of the drying process and transit to circularity.

- Develop smart farms: 70% of global water withdrawal is used by agriculture (World Bank). Smart farms are trending for their water use optimization, achieved by analysing soil moisture with IoT sensors or drone imagery for precision agriculture. Its demand is expected to grow and reach a market value of 34.1 billion dollars by 2026 and, more importantly, it will help to optimise costs, resources consumption and reduce the environmental impact of traditional practices.

Collaboration

There is increasing collaboration between different sectors, such as government, business, and civil society, to address food waste.

- Public-private partnerships: Governments can work with businesses to implement food waste reduction initiatives. For example, a government might partner with a grocery store chain to donate excess food to a food bank or provide funding for the store to implement food waste reduction strategies.

- Cross-sector coalitions: Governments, businesses, and non-profits can come together to form coalitions to address food waste. These coalitions can pool their resources and expertise to develop and implement food waste reduction strategies.

- Public education campaigns: Governments, businesses, and non-profits can collaborate on public education campaigns to raise awareness about food waste and encourage people to reduce it.

- Research partnerships: Governments, businesses, and universities can collaborate on research projects to develop new technologies and strategies to reduce food waste.

- Community-based initiatives: Governments, businesses, and non-profits can work with community organizations to implement food waste reduction initiatives at the local level. For example, a government might provide funding for a community group to start a composting program, or a business might donate excess food to a local food bank.

Overall, there is growing recognition of the problem of food waste and a number of efforts underway to address it.

Initiatives to reduce food waste targeted at different stages of the food system

The following initiatives are classified according to the food systems chain stage in which they can be applied.

Primary production

- Consumption of out graded and about to expire food.
- Short supply chains and regionalisation of food production.
- Storage improvements.
- Use of by-products for animal feed production.
- Taxation policies on food waste disposal.
- Access to modern equipment and techniques.
- Fishing: A policy reform and use of selective fishing gear.

Food processing and packaging

- Policies for resale/use of 'sub-standard' products.
- Application of date marks (more accurate date labelling).

Wholesale and logistics

- Electronic ordering systems and automatic storage management systems.
- Advanced packaging (conservation and transport techniques).
- Improve distribution (and redistribution to food banks) logistics.
- Incentives to reduce disposal and increase redistribution.
- Logistic more attentive to food safety
- Development of business models around imperfect produce.

Retail and markets

- Food donation & redistribution programmes
- Reduce prices on sell before /best before date products
- Alternative use of products
- Limits to price promotions with discounts on volumes
- Purchase per weight of fruit and vegetables
- Improve and guarantee food safety standards
- Improve refrigeration techniques
- Consumer awareness
- Improve organics collection services

Food Services

- Encourage consumption of leftovers and use of doggie bags
- Reduction of menu variety
- Improve demand forecasting and ordering systems
- Menu quantities based on hunger / size

Households

- Improve waste collection infrastructure
- Education programmes on diet and cooking
- Local composting facilities and services

Legal Barriers to Food Waste Circularity

There are several legal barriers to food waste circularity. For example, food safety regulations can make it difficult to create novel food, repurpose or donate food that is past its expiration date, even if it is still safe to eat. Businesses may be hesitant to donate or repurpose food due to concerns about liability in the event of food-borne illness. Pre-market authorization of novel foods is required, as they must comply with consumer safety

standards. If the novel foods are intended to replace another food, they must not differ in such a way that consumption of the novel food is nutritionally disadvantageous to the consumer. Regulations on food labelling and packaging are very strict both for novel foods and for repurpose food.

European zoning regulations may also put barriers for businesses and organizations to implement on-site food waste management programmes. These regulations can limit the use of land for certain activities, such as composting or anaerobic digestion, and may make it difficult to locate facilities that can process food waste on-site. Zoning regulations vary by country and region; therefore, it is worth to consider:

- **Air quality regulations**- may limit the emissions of odours and pollutants that may be associated with composting or anaerobic digestion, and may make it difficult to operate facilities that process food waste on-site.
- **Noise regulations-** may limit the noise levels associated with composting or anaerobic digestion, and may make it difficult to operate facilities that process food waste on-site.
- **Waste management regulations-** may limit the amount of waste that can be processed on-site, and may make it difficult to compost or anaerobically digest food waste on-site.
- **Water quality regulations-** may limit the discharge of pollutants associated with composting or anaerobic digestion, and may make it difficult to operate facilities that process food waste on-site.
- **Building codes**- may limit the construction of facilities that process food waste on-site.
- **Fire safety regulations**- may can limit the use of certain types of materials in the construction of facilities that process food waste on-site.

Moreover, there are several legal barriers to deploying tech pilots in European cities and rural communities. These include:

- **Privacy and data protection laws**: European Union has strict laws regarding data protection, such as the General Data Protection Regulation (GDPR), which can make it difficult to collect and use data in smart city projects.
- **Regulatory barriers**: There are often different regulations and requirements for deploying technology in different cities and regions, which can make it difficult to roll out pilots on a larger scale.
- **Liability and safety concerns**: There are potential liability and safety concerns when deploying new technology in public spaces, which can make it difficult to secure funding and insurance for pilot projects.
- **Procurement laws**: EU countries have different procurement laws and regulations which can make it difficult for companies to bid for and win contracts for smart city projects.
- **Interoperability**: lack of standardization of infrastructure and software across EU countries can make it difficult to ensure that different smart city systems can work together effectively.

However, there are other European waste management regulations that aim to reduce the amount of waste generated and promote recycling and recovery of waste materials. Some examples of these regulations include:

- EU Waste Framework Directive (2008/98/EC): This directive sets out the overall framework for waste management in the EU, including the hierarchy of waste management options (prevention, preparing for re-use, recycling, recovery, and disposal) and targets for recycling and recovery of waste materials.
- EU Packaging and Packaging Waste Directive (94/62/EC): This directive sets targets for the recycling and recovery of packaging waste, and requires producers of packaging to take responsibility for the management of their packaging waste.
- EU Landfill Directive (1999/31/EC): This directive sets targets for the reduction of biodegradable municipal waste sent to landfills and sets standards for the design, operation and closure of landfills.
- EU End-of-Life Vehicles Directive (2000/53/EC): This directive requires vehicle manufacturers to take responsibility for the environmentally sound treatment of end-of-life vehicles.
- EU Battery Directive (2006/66/EC): This directive regulates the collection, treatment and recycling of batteries and accumulators, to minimize the impact of batteries on the environment.
- EU Waste Electrical and Electronic Equipment Directive (2012/19/EU): This directive regulates the collection, treatment and recycling of waste electrical and electronic equipment, to minimize the impact of waste on the environment.
- EU Circular Economy Package: This package of legislation adopted in 2019, set targets for recycling and recovery of municipal waste, packaging waste and specific waste streams, such as textiles, and established measures to reduce the generation of food waste.

All these regulations aim to encourage the use of sustainable waste management practices, such as reducing, reusing, recycling, and recovery, and to minimize the environmental impact of waste. They also establish targets for waste management and recycling that EU member states must meet and also create a legal framework for the prevention of waste, waste reduction and the implementation of the circular economy principles.

Conclusion: Future Scenarios for Food Waste

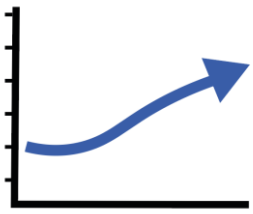
If the world population and economy continue to grow, it is likely that food production and consumption will increase. This can lead to more food waste, as well as more pressure on food systems to be more efficient. Climate change and other environmental challenges can also affect food production and distribution, leading to more food waste. However, technological advances can help reduce food waste by improving food storage and preservation methods, as well as making it easier for consumers to track and manage their food consumption.

Social and cultural factors are key to reducing food waste, as changing social and cultural attitudes play a crucial role in shaping the future of food consumption. As people become

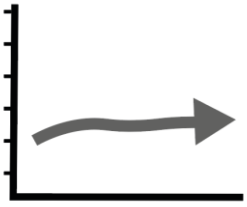
more aware of the environmental and economic impacts of food waste, they are more likely to take steps to reduce it.

Government policies, regulations and laws can have a huge impact on food waste. Policies that incentivize or require the reduction of food waste can have a large impact on the problem.

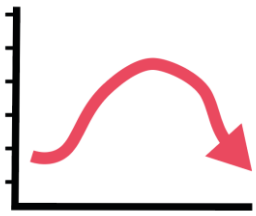
It is difficult to predict the exact future of food waste, as it will depend on a number of factors, however, here are a few potential future scenarios:



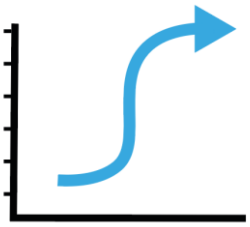
Continued progress:
If current trends continue, it is possible that food waste will continue to be reduced as awareness of the issue grows and more people and businesses take steps to reduce their own food waste.



Plateau:
It is possible that progress in reducing food waste may plateau at some point, as it becomes more difficult to make further gains. This could be due to a lack of incentives or technological limitations.



Reversal:
If efforts to reduce food waste are not sustained or if there is a significant increase in the global population, it is possible that food waste could increase in the future.



Radical change:
It is also possible that technological innovations or major shifts in societal values could lead to radical changes in the way food is produced, distributed, and consumed, resulting in significant reductions in food waste.

Overall, the future of food waste is uncertain, but it is important for individuals, businesses, and governments to continue working to reduce food waste and create more sustainable food systems.

Case Studies: What will be needed in the future?

Sunqiao Urban Agricultural District

Fig. XX: Sasaki Architechts

Sasaki is an international architecture firm working on urban agriculture. Their work includes the Sunqiao Urban Agricultural District, which is integrating vertical farming systems in public facilities in the area. This approach is a divergence from the theoretical skyscraper farms into more practical applications of urban farming. Also emphasized in the project, is the relationship between architect and municipalities, as this communication is pertinent to meaningful change. Through this dialogue, it can be discovered what spaces are most underused and the best fit for the installation of vertical farms or other practices. https://urbannext.net/how-food-will-reshape-our-cities/

Re-plate (California): Alleviating food insecurity

Replate manages the food donations of caterers, offices with meal services, brands with product overrun, farmers markets, restaurants and other surplus food generators. Every food donation is taken to a nearby nonprofit that works with people experiencing food insecurity.

The company leverages data, artificial intelligence, and agile programming to recover surplus food from vendors and deliver it directly to non-profit organisations.

https://www.re-plate.org/

Zero Waste Europe

The project has been set up to investigate practical ways to achieve zero waste to landfill in the South East of England. It will share the results with colleagues both in the UK and in relevant EU Member States. Zero waste in this context is an approach to supporting the sustainable use of resources by business to benefit both the economy and the environment. It concentrates on reducing, re-using, recycling and recovering energy from waste.

https://zerowasteeurope.eu

Bowery Farming

Fig. XX: Bowery Farming

Controlled Environment Agriculture is an important part of urban farming. CEA is farming in a controlled set of conditions including humidity, temperature, light, and nutrients. It is used in indoor farms so that multiple types of crops can grow in their ideal conditions in one building. Bowery Farming uses a combination between CEA and Vertical Farming in order to produce their crops. The latter takes advantage of tall warehouse type buildings to create stacks of crops. Bowery does not use soil but instead a mixture of hydroponic, aeroponic, and aquaponic methods. They also use LED lighting instead of relying on the sun for the necessary photosynthetic source.

Advantages:

Water Usage: Unlike outdoor farming, vertical farms can recirculate the water in their irrigation system to reduce water waste.

Arable Land: Bowery avoids issues caused by loss of arable land by converting industrial spaces into their indoor farms and staking their crops to multiply their yield per square foot.

Food System: These indoor farms are located outside of cities and can produce their crops year round. Therefore, there exists less risk for breakdowns in the food transportation system that harm communities.

Food Safety: E. coli outbreaks and other irrigation related health risks can be avoided.

The Bowery Farms grow only leafy greens and are just now branching into vine fruits such as strawberries. They are working on growing solutions for other types of farmed goods. Because of the current limitations on crops and the space and resources available to companies like Bowery Farming, indoor farming is not enough to feed the world. However, it can be one part of the global food systems challenges.
https://boweryfarming.com/vertical-farming/

Veolia

Fig. 06: Veolia

Veolia is a for-profit business working on innovative ecological solutions in the industries of waste, water, and energy. They are partnering with organisations in a few major cities in order to develop urban farming practices and invest in a circular economy. They work with a food market in Brussels, Belgium and their roof garden of 2.000 sq metres of green houses and 2.000 sq metres of outdoor gardens. Through aquaponics, they produce over 30 metric tons of fish and 15 metric tons of tomatoes annually. Their mission is to contribute to the circular economy in Brussels and to provide for their community with as little waste as possible. Veolia also partners with Espaces and the Culticime project in an urban community garden atop a shopping centre in Île-de-France. This project provides jobs for people returning to the workforce. Their general focuses of all the projects they support are urban permaculture, aquaculture, and aquaponics.
https://www.veolia.com/en/solution/urban-farming-solution-helping-feed-cities

ReuSe Vanguard Project

Food and drinks account for the generation of 90% of waste of packaging, and much of it strictly responds to the needs of the distribution and sales chains, and does not guarantee the right to consume without producing waste.
This project has created an urban logistics service of reuse of containers for fresh food, supported with technological partners, which has allowed to create of hardware products (process automation gadgets like the autonomous return of packaging, the identification and registration of users and packaging, and the optimization of cleaning processes), and software (in logistics functions, database management, traceability, online payments, notifications).
https://zerowasteeurope.eu/our-work/implementation-activities/reuse-vanguard-project-rsvp/

Es im-perfect (Barcelona)

Fig. XX: Es im-perfect

Es im-perfect® is the range of products and the job placement company of the Espigoladors Foundation, an initiative that, since 2014, has acted on three social needs at the same time and connects them: fight against food loss and waste, guarantee the right to healthy and sustainable food for the entire population and create job opportunities for groups at risk of social exclusion.

https://esimperfect.com

Ottan Studio (Turkey): Upcycling food waste

Fig. 09: Ottan Studio

An impact startup focused on up-cycling green waste into high-quality materials to be used in interior design and industrial design products. Ottan Studio converts food and garden waste into bio-composite material from which it makes furniture, decorative items, and wall panelling.

https://www.ottanstudio.com/

BIO2CHP (Greece): Waste-to-energy strategy

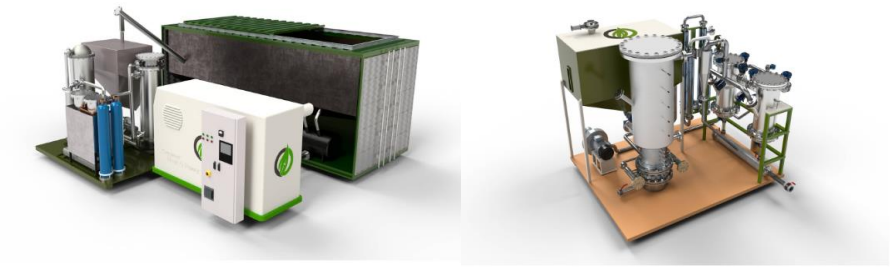


Fig. 10: BIO2CHP

Bio-based Energy Technologies P.C. (BIO2CHP) is a university spin-off company, established in 2017, with the main purpose of bringing to the market a technology which enables the use of raw residual biomass for the small-scale & on-site energy production. Utilises raw residual biomass feedstock from the agro-food industry – especially fruit waste, coffee grounds, and olive kernels – for small-scale, on-site electricity production.

http://www.bio2chp.com/

WeFood: the first-ever surplus food supermarket

Fig. 10: Source: WeFood.

This supermarket aims to cut down on the massive amounts of food wasted every year—700,000 metric tons in Denmark, and 1.3 billion metric tons around the world. The supermarket has prices up to 50% lower than any other grocery store in the city, drawing both environmentally conscious shoppers and low-income individuals with limited budgets.

These initiatives benefit both consumers and the planet, preventing tons of food from ending up in landfills.

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