Case study: application of a sustainable circular food waste and loss business model in Barcelona.

Maria Romeu Arumí

Tutor: Lela Melón, Carolina Luis Bassa

Project code: ECI03

Academic year: 2021-2022

Degree: International Business Economics

Table of contents

Acknowledgments

I would like to express gratitude to Lela Melón, the executive director of the Planetary Wellbeing Institutional Framework at Universitat Pompeu Fabra and professor of sustainability in ESCI-UPF, for tutorizing this final year project and providing support and guidance.

Moreover, I would also like to thank my colleagues Candela Esposito, Minami Seki, and Ilin Kim, for letting me continue with the action plan[1] we started on the circular economy course of BaPIS.

Last but not least, I would like to show appreciation to all the people who spent their time participating in the survey I conducted.

Executive summary

This end-of-degree case study examines the implementation of a sustainable circular business model in the city of Barcelona. It first gives an overview of the impacts that a linear food system has mainly on the environment and how food losses and waste also contribute to damage it. Some solutions are presented in order to tackle those issues. Subsequently, a circular business model is presented as a potential resource to prevent the problem of food waste and to keep organic waste in the loop in the city of Barcelona, so its highest value is maintained. An analysis of Barcelona and its peri-urban area is conducted to estimate whether it would be viable in the area or not. Assessing its geographical position, food production, food consumption, and waste flows and prevention. Following it, specifications of the circular business model are provided, explaining in detail which are the tasks of the different stakeholders. Finally, the economic viability of the model is presented, to ensure it would be realistic to implement it. All in all, the paper analyzes the viability of creating a sustainable circular business company that aims to have a positive impact on both society and the environment.

Keywords: food waste, food loss, city, circular economy, sustainability regenerative practices, Barcelona, AMB

1. Introduction

Climate change is a current topic that affects all of us. Many people are not aware of the real implications of it and thus do not take action to try to mitigate or prevent it. Considering myself very conscious of the issue, my topic for the final year project had to be related to it. Given the fact that climate change is connected somehow to almost every single sector and industry, I also wanted to tackle other issues, and the food industry suits this purpose since it encompasses one of our biggest challenges, hunger. It is clear that the current food systems do not work well. While many people are

[1] C.Esposito, M.Romeu, M.Seki and I.Kim, 2022. *Circular Economy Action Plan on Prevention of food waste in the city of Barcelona.* [online]

left without food (10% worldwide population), ⅓ of the food for human consumption is wasted (Food and Agriculture Organization of the United Nations, 2011). Moreover, the environment is being damaged and industrial agriculture is one of the leading sources of pollution, greenhouse gas emissions, and biodiversity loss (Ellen MacArthur Foundation, 2022). The industry furthermore depends on a huge amount of synthetic fertilizers, pesticides, fresh water, fossil fuels, and other finite resources. It is clear that these practices are not sustainable in the long term and that a redesign of our food systems is needed. As noted by the Ellen MacArthur Foundation, "*A circular economy for food will help people and nature to thrive.*" Therefore, changing into a circular food system, which does not produce waste, will help tackling climate change at the same time as providing healthy food for everyone, generating new economic opportunities, and adjusting to new challenges, such as a growing population. Moreover, 50% of the world population already lives in cities and it is expected that by the year 2050 the percentage can increase to 75%. Cities accumulate materials and nutrients and are responsible for 75% of the consumption of natural resources, generate 50% of municipal waste, and produce 60-80% of greenhouse gas emissions (AMB, 2022). Considering that cities play an important role in the transformation of the food systems, the aim of this project is to analyze whether a circular business model based on food waste would work in the city of Barcelona or not.

1.1. Methodology

The methodology for this final year project is basically based on secondary sources. Firstly, a theoretical framework based on secondary sources (mostly from the Ellen MacArthur Foundation) will be provided to analyze the impacts of the linear food system and the impacts of food loss and waste. When possible, the repercussions of those issues in the city of Barcelona will also be assessed. Theoretical solutions to tackle the problems will be presented. More in-depth, one will present the new circular business model. In this step, only an idea and a general overview of the strategy will be provided, together with a diagram of the food supply chain and the functioning of the new business model.

Thereafter, an analysis of the city of Barcelona and its peri-urban area will be carried out. It will be a theoretical framework based on the city analysis instructions provided by the Ellen MacArthur Foundation Cities and Circular Economy for Food. Information will be extracted from secondary sources, mainly from the Generalitat de Catalunya, the Àrea Metropolitana de Barcelona databases, or the Agència de Residus de Catalunya. Within this second step, a survey has been done in order to analyze the food consumption habits in the city of Barcelona and it is used as a primary source to gather information for the paper. Afterward, one will provide the specifications of the model, distinguishing the two different main products that will be manufactured, food preservatives and

compost or organic fertilizer. Finally, the economic viability of the model and its sources of competitive advantage will be presented.

1.2. Limitations

Throughout the project, significant limitations have surged that need to be noted from the beginning. By way of example, it has been challenging to find some of the information needed for the Barcelona city analysis, as some of the indicators did not exist or the ones available were outdated. Due to this, the data provided is not homogeneous in terms of its timeliness, yet it has been used to carry out a qualitative analysis supporting the findings of the present work.

In terms of limitations related to the practical framework, two limitations are very defined. On the one hand, within the interview, since I am not from Barcelona, I do not know many people from there and it has been difficult to obtain respondents for the survey. Although I have obtained almost approximately 100 answers, the survey is not representative of the Barcelona population since most of the participants were students. More information regarding it will be presented later. On the other hand, one wanted to do an interview with *Espigoladors*, a Catalan company found while doing research, which is basically already implementing a similar circular business model to the proposed one. Although I have been able to get in contact with them, they were too busy and in the end, the interview could not be carried out.

2. Preamble

There are three main current challenges to the current food systems, which range from environmental to socio-economic and technological ones.

The **environmental challenges**, on the one hand, are related to climate change, such as extreme weather conditions which can damage crops; and deforestation and biodiversity loss, which reduce the resilience against those climate phenomena. On the other hand, are related to resource scarcity, which contributes to contamination and reduction of water resources; and the increase in energy consumption, which is not suitable with today's supply chain lengthening (INÈDIT, 2017).

The **socio-economic** ones claim that for 2030, the food supply will have to increase by 50% to cope with the increase in population. It will also have to deal with an aging population and the rural exodus, which challenges cities' ecosystems, and thus, new food systems will be needed. Related to it, empowered consumers are asking for more transparency and for healthier products with greater environmental sustainability. At the same time, they are asking for new diets and facing the boom of electronic commerce.

The **technological** ones are presented more like a changing force towards a more efficient value chain that will properly use resources and will improve traceability (INÈDIT, 2017).

As shown in ***Figure 1*****,** the food industry is one of the sectors with a greater contribution to the Catalan economy (it represents 17% of the overall Catalan GDP) and at the same time, is the one with the greatest potential to introduce circular practices. (FundaciónForumAmbiental, 2017). Therefore, one can observe how important the food industry is and how easy would it be to change its linear practices compared to other industries.

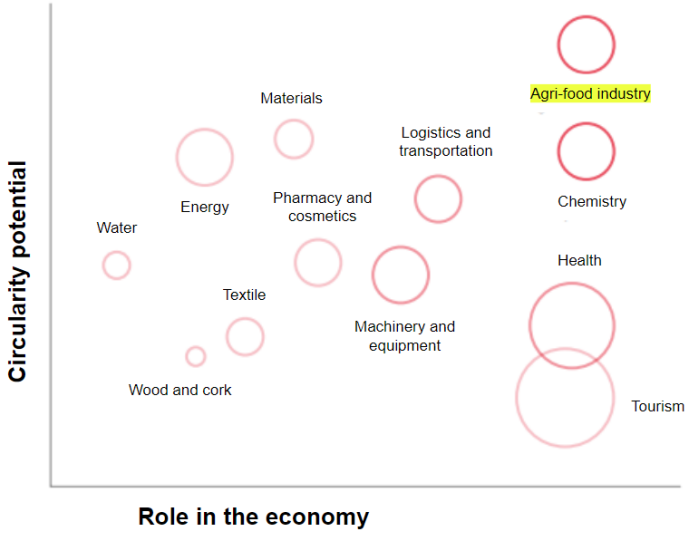

Figure 1: Strategic sectors for circular economy in Catalonia. *Source:* Fundación Fórum Ambiental, 2017. <http://laboratorioecoinnovacion.com/publicaciones/guias-de-economia-circular>

2.1. Impact of the linear food system

The current linear food system negatively affects local ecosystems, agricultural land, human health, and economic outcomes. Indeed, for every dollar spent on food, society pays two dollars in health, environmental and economic costs, totaling USD 5.7 trillion of costs globally. These costs come from the extraction of finite resources and the use of fossil-derived materials to produce food. Also, among the 7.1 billion tonnes of food produced yearly all over the world, 2.8 billion tonnes of it are wasted in cities. Less than 2% of the biological nutrients contained in this organic waste are captured, treated safely, or valorized. Those which are not valorized are destined for landfills, incinerators, or open dumps, where they negatively affect neighbors and the environment. Moreover, costs also come from polluting the environment (air, water, and soil) generated by the use of pesticides or chemical fertilizers used to produce food. The linear food system also degrades natural resources on which it depends. For instance, half of the world's habitable land is used for agriculture and the use of harmful practices is degrading 39 million hectares of soil globally each year and only 60 years of farming are left if we continue with these practices (Arsenault, 2014). At the same time, it is expected that by 2050, 5 million people will die because of the current food system, which will be caused mainly

because of air pollution, water contamination, pesticide use, or antimicrobial resistance (Ellen MacArthur Foundation, 2019).

Moreover, it is estimated that 26% of global GHG emissions are produced because of the food industry (Poore & Nemecek, 2018). In order to meet our long-term needs, the application of a circular food system is needed and requires a change in the way we produce and consume food.

2.2. Impact of food losses and waste

The food industry produces a huge amount of food which is wasted, around 33%. The sector produces negative impacts on the environment, for food that is not even consumed, so it is very inefficient. Indeed, 6% of global greenhouse gas emissions come from food that is never eaten (Poore and Nemecek, 2018) and 10% of worldwide energy consumption is to produce food that is never eaten (INÈDIT, 2017).

The loss of food is mainly generated in its production phase in the Global South, due to a lack of infrastructure, deficient technologies, and too little investment. Food waste in Global North is mainly generated in its consumption, 42% of food waste is generated in households in Spain (INÈDIT, 2017). Although, the other main source of GHG emissions related to food waste is the one that comes from the methane that rooting food waste produces in landfills, being 25 times more powerful than CO2 (Sauve & Van Acker, 2020).

However, governments are trying to cope with this issue by setting actions to prevent food waste and trying to decrease its impact on the environment. In the following ***Figure 2***, one can observe that the carbon footprint has been decreasing in Catalonia since 2013 (except 2016), thanks to the increase in the selective waste collection system and the decrease of depositing waste in dumps during its treatment (ARC,2019).

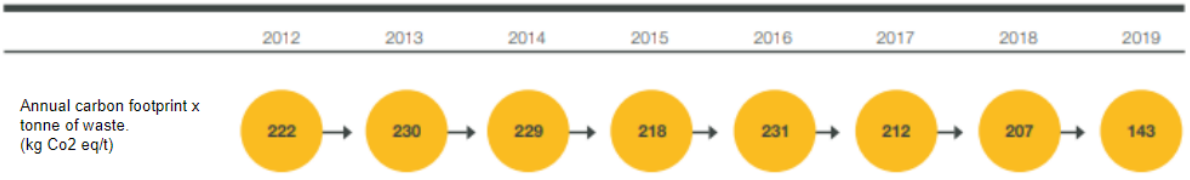

Figure 2: Evolution of carbon footprint associated to waste treatment x habitant and tonne of waste. Source: ARC, 2019. *Datos de residuos en Cataluña.* <https://residus.gencat.cat/web/.content/home/lagencia/publicacions/estadistiques/estadistiques_2019_es.pdf>

2.3. Possible solutions

Having presented the aforementioned issues regarding food waste, there are mainly two ways to build a better food system, according to the Ellen MacArthur Foundation.

On the one hand, transitioning towards a circular economy undertaking a **regenerative food system** which at the same time builds natural capital and allows nature to thrive. The overall idea of regenerative food production is that it resembles natural ecosystems such as forests. Growing food in such a way that contributes to positive outcomes for nature. For instance, the following advantages are attributed to a regenerative food system:

- Enriching local microbial biodiversity, by providing habitat for a huge variety of organisms and by decreasing the use of synthetic fertilizers and pesticides.
- Building healthier soils, which help to restore the natural carbon cycle, enabling the soil's ability to sequester carbon and fight against climate change.
- More resilient food supply, by making harvests more reliable and resilient in the long term. With the diversification of the types of crops consumed, the food system is more able to withstand shocks.

There are several agricultural practices that drive regenerative outcomes, the ones adopted will depend on the local contexts that suit them best. The most important ones are agroforestry, rotational grazing systems, use of organic inputs, increasing crop diversity, and minimization of soil disturbance (Ellen MacArthur, 2022).

On the other hand, **eliminating food waste** is named as second-best, which can be achieved by designing a circular model which guarantees that our food never generates waste. Three solutions can be presented. First, preventing edible food waste and loss, such as extending the shelf-life of fresh products or managing a better allocation of purchased food by restaurants. Second, redistribution of edible food for human consumption. Third, transforming inedible food, by-products or edible human waste into new things, depending on the local context and demand. Those include[2] other food ingredients, inputs for agriculture or new biomaterials such as packaging.

For those solutions to work out in the new food system, there is a level of collaboration needed between several actors. Brands and manufacturers and restaurants need to redesign food products or menus respectively, by using ingredients made from food by-products. Retailers must improve their logistics to prevent edible food waste such as trying to match food volumes to demand or redistributing food waste. Cities and governments must develop policies which incentivize the practice of circular economy actions and must provide with the necessary infrastructures for organic waste collection and to bring organic fertilizers from urban waste to peri-urban farms. Farmers must change some of their practices towards the reduction of waste and must use organic fertilizers. Lastly, but not less important, resource and waste management companies must also provide the infrastructure to

[2] It is important to consider that energy generation through the incineration of organic waste on its own would not be a circular economy process. Thus, it is not included here.

bring the organic fertilizers to the farms, must innovate the organic waste collection and treatment system, and work with public and private sectors to create new valuable products made from their food by-products (Ellen MacArthur, 2022).

3. Presentation of the food circular business model

3.1. Idea and strategy

The circular business model is similar to the *es-imperfect* model from *Espigoladors*. The main aim is to feed Barcelona's city population in the context of resource scarcity and food waste. Under the effects of climate change, the main aims are to optimize the production processes by closing loops with consumers and suppliers, to work in local surroundings, and to provide regenerative practices to nature. To do it, new agricultural methods, alternative protein sources, different ways to preserve food, an efficient supply chain, new packaging solutions, and an adaptation of products to the preferences of consumers will be needed.

The business model will be based on two interconnected cycles. On the one hand, it is based on the collection of soon-to-expire, overripe, and “ugly” fruits and vegetables from farms, markets, and stores in the peri-urban area of Barcelona. With these raw materials, preserved food will be produced in the area and will be sold in the stores where the raw materials will have been collected. Thus, the life of the raw materials will be extended, providing them with more value. Moreover, elderly people will participate in the project by providing their knowledge in the field of preventing food waste, giving them the chance to share their best food recipes and tips to prevent food waste.

On the second hand, it is based on the collection of inedible food waste which will be gathered either from the collaborators of the previous cycle or from external individuals who will bring their organic waste into the collection points that will be set up in the stores where products are sold. With these collections, organic fertilizer and compost to regenerate the natural environment will be produced and will be redistributed to farmers and individuals. A diagram of the business model can be found in the annex, ***Figure 3***.

Moreover, in ***Figure 4***, one can observe the usual food supply chain and the details of what the CE business would do in each step. It is remarkable that up to industrial transformation, we are talking about the collection of food loss, and from distribution, up to consumption, we talk about food waste. All in all, food waste and food loss are collected and transformed into new products which follow the food supply chain again. It must also be considered that inedible food waste would also be collected from the collection and treatment of raw materials, the industrial transformation, and the commerce, as stated in figure 3, with an underlying focus on the consumer.

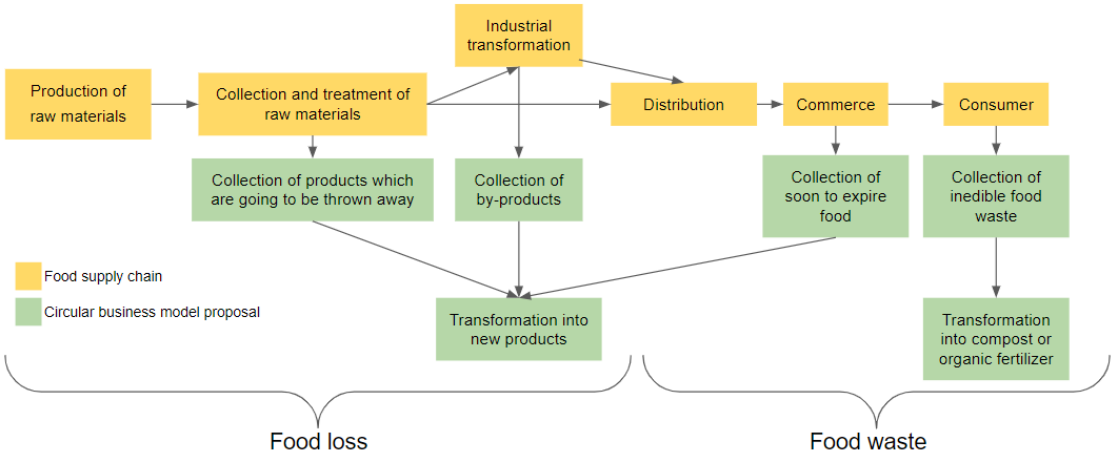

Figure 4: Food supply chain and circular business model function. Source: own production.

4. Barcelona city analysis

An analysis of the city of Barcelona will be provided in the following section. Barcelona has been chosen for the application of the circular model because of its commitment to the agenda 2030 and the sustainable development goals, its pledge to reduce inequalities, and its innovative environment. Barcelona is willing to transform into a sustainable and fair city. Its main aspirations are the following: being an international city, sustainable, responsible, feminist, and a creator of green jobs (Barcelona Activa, 2020). Moreover, in 2021, Barcelona has been considered the Worldwide Capital of Sustainable Food (Alimentació Sostenible, 2022).

This analysis is based on the city analysis guide of the Ellen Macarthur Foundation[3], which presents a six step-by-step approach to enable cities to develop scenarios and estimate possible outcomes and benefits. It has been adapted for the purpose of this project, and not all the steps will be analyzed. In order to comprehend this section, it is important to read at the same time the Barcelona city analysis found in the Annex.

4.1. Understanding the city archetype and surrounding region

Considering the classifications of the Ellen MacArthur Foundation, Barcelona and its peri-urban area are considered to have an archetype of a stable community, due to the small population size, the low population growth and, the high GDP. Moreover, it is clear that the city and its peri-urban area show great potential for the implementation of a circular model for food due to its localization and territory, on the one hand, which includes the agricultural areas of the Llobregat delta, the large green areas of the massifs of Garraf and Collserola, the Marina mountain chain, the Besós and Llobregat rivers, and

[3]Ellen MacArthur Foundation, 2019. Cities and Circular Economy for Food, city analysis instructions. Source: <https://emf.thirdlight.com/link/mw02glgs335s-xmt5kq/@/preview/1?o>

on the other hand due to its reliance on services and its increasing trend in GDP growth which opens room for innovation in the sector.

4.2. Assess urban and peri-urban food production

Production of food in the area represents only 2% of the total food consumed. Already 14% of the population in the area is not able to afford a healthy and diverse diet (Agència Metropolitana de Desenvolupament Econòmic, 2019). Changes must be made in the production of food in the area to solve current challenges and to make the area more capable to feed itself in the future. It has to be accounted that throughout the years, the agricultural area has decreased, almost 15-30% of it has been abandoned and some of it has been converted into urban areas. Agricultural production is mainly concentrated in the Baix Llobregat agricultural park and the Collserola mountain chain agricultural park. Both are moving towards more sustainable practices. Given the fact that the agricultural area of the peri-urban area of Barcelona is small, new techniques and processes will have to be designed to make food production as big and profitable as possible. For example, implementing initiatives such as urban gardens, which have clearly increased during the last years.

Food processing is also very important in the area: 38,752 tonnes of food are produced yearly in the city. It is interesting to know that 170,259 tonnes of edible food waste were recycled to produce more food. The overall food industry in the area has big potential since it represents almost 40% of the Catalan food industry (Associació Arran de Terra, 2018). Indeed, the number of people working in the overall food industry in the peri-urban area of Barcelona, directly and indirectly, is 160,000 people (Agència Metropolitana de Desenvolupament Econòmic, 2019). Moreover, it is clear that a circular model would be able to be implemented because of the existence of ecological farms which would generate food loss, would need compost, and would need organic fertilizer. Also, the presence of common workshops, impulsed to incentivize agricultural local practices and to create synergies would benefit the company in the production of the new food products. All in all, the main challenges are to preserve the agricultural diversity, to make sure that future generations keep on working the land so there is a generational replacement, and to establish new techniques which ensure food security while at the same time reducing the cycles.

4.3. Assess urban food consumption

For this business model, only domestic food consumption will be considered, as 6,368,536,542 euros were spent on domestic food consumption in 2019 in the area (Institut Cerdà, 2019). One of the biggest challenges for the circular business will be to simplify its logistics and distribution processes and make them more efficient and sustainable. Logistics in the area is basically done throughout

Mercabarna but the idea is to not collaborate with them. Different distribution channels exist, which will be given importance when talking about consumption habits.

4.3.1. Consumption habits

The consumption habits of people in Barcelona are explained in depth in the Annex to the present work, which allows for understanding of the overall food consumption in the area. The present section provides an overall analysis of the consumption habits of ecological products. Thanks to the 2020 barometer[4] of perception and consumption of ecological food made by organizations such as Generalitat de Catalunya, an overview of the relationship between the Catalan population and ecological food is provided for. Most of the participants in the survey (74%) were from Barcelona, so it is perfect to extract conclusions for this project. Moreover, some information from the survey conducted will be used to complement the analysis.

It is said that 83.2%[5] of the Catalan population knows and classifies in a good way what is an ecological product[6]. Among those who know what an ecological product is, 59.2% do not buy them and 40.8% buy them. Being therefore the main reasons for buying those products over other conventional ones, healthy reasons (68.6%) and environmental reasons (25.5%). Similar results were found in the survey. Moreover, when choosing over different ecological products, consumers state that they base their decisions on the information on the labels (67.7%), the origin of the product (49.8%), and in the third position, its price (7.9%).

When talking about consumption, 46.8% of the participants consume organic products, considering those who do it daily (7.7%), weekly (26.11%), and monthly (13%)[7]. So, almost half of people consume organic food, and this trend has been increasing. For instance, from 2017 to 2020, there was an increase of 23.3% of the population who ate it. Also, one-third of participants in the survey who already consume ecological products, stated that they will increase their consumption, and those who have never consumed them, showed an interest in the consumption of these products in the future. All respondents in the survey claimed they are willing to eat more ecological food. Vegetables (76.6%) are the ecological products that are consumed the most and eggs (72.1%) and fruit (69.5%) follow.

[4]CCPAE, 2020. *Baròmetre 2020 de Percepció i Consum dels Aliments Ecològics*. [online] Ccpae.org. Available at: <http://www.ccpae.org/docs/consumidors/barometre_percepcio_consum_aliments_ecologics_2020.pdf>

[5] In the survey conducted, only one individual did not know what an ecological product is. Interesting to observe that it corresponds to a student and that is not responsible for the purchase of food in her household.

[6]Most of them relate them with positive aspects such as being natural products (18.8%) , without chemicals (15.1%), that respect the environment (13.8%), healthy (13%) and without pesticides (13%). Although, there are some people who relate them with negative aspects, the most typical one being high prices (15.1%).

[7] On the survey, results were similar, being 6.7%, 41.6% and 21.3% respectively.

Why do people who know about organic food not buy it?

The main reason claimed by the interviewees (53.4% of them) is because of its price[8]. The second reason (12.9%) is about the lack of presence in shops and the third one is regarding its difficulty to find (11.7%). Those percentages have been decreasing over the years, meaning that sellers have taken into consideration the demands and have adapted to their needs[9].

Of the usual buyers of food, 41.8% state that they are willing to pay a higher price to buy ecological products, because of their benefits. It is interesting to note that 57.7% of the purchase of ecological products would be incentivized by the decrease of their prices, 37.7% by making those products more accessible in usual shopping places, and 24.5% by increasing the variety of products[10].

Expenditure on ecological products

Buyers of ecological products are allocating more and more of their weekly expenditure on ecological products, the average being 34.4%. The ratio of people spending more than 30% of their basket on ecological products has increased by 5.2% in comparison to 2019, representing 41.9% in 2020 and showing an increasing trend.[11]

When buying// positioning

Fresh products and good labeling is said to be always found in ecological products by more than 80% of the respondents. On the other hand, 42.8% of the respondents stated that the seller has never informed them about the product and 31.9% have not seen the product neither appealing nor attractive.

Where to buy ecological products

According to the Omnibus 2020 survey, local food is bought in supermarkets (33%), local shops (31.9%) and markets (24.7%); and ecological food is bought in local shops (40.6%), supermarkets (28.9%) and markets (15.5%) (Ajuntament de Barcelona, 2021). It is also interesting to observe that 80.4% of the usual buyers of ecological products state that there has been an increase in the offer of ecological products in all shops, a similar result has been found in the survey.

[8] Indeed, 94.9% of buyers of ecological products believe they are overpriced, from 19% extra price up to 34% (being prepared food the most overpriced).

[9] Results on the survey stated that the first reason is price, followed by lack of information and lack of presence in shops.

[10] It is interesting to observe that in the survey conducted, products found in usual shopping places was the option voted by more respondents (65.2% of them), followed by cheaper products (64%) and produced in proximity (15.7%).

[11] Although, results obtained in the survey are not as optimistic as those. Those spending more than 30% of their basket on ecological food only represented 13.5%. A 40.4% for those spending less than 15%, 27% for those spending 15-30% and a 19.1% did not know their expenditure on ecological food.

4.4. Determine urban organic waste and food by-product streams

4.4.1. Waste flows

While overall waste has increased throughout the years in the peri-urban area of Barcelona, the proportion of organic waste has been decreasing. When talking about food waste, 1.183 million tonnes are residual food waste and 260,000 tonnes are edible food which is thrown away. The majority of it (58%) comes from residential sources, so it is clear that consumers play an important role in managing food waste. Although, they do not have everything under control. For instance, packaging must need good standards to ensure the best food quality preservance. The collection scheme of waste in Catalonia seems to be more effective each year but there is still work to be done in order to make people use it properly. The amount of waste collected separately increased by 28.4pp from 2000 to 2020 in Barcelona, so there is room for improvement. Waste treatment is making a positive evolution in the peri-urban of Barcelona. For example, there is almost no deposit of waste, and 60.6% is managed throughout biological mechanical treatment. We can find 12 waste treatment plants in the peri-urban area of Barcelona. Although, it is clear that if waste keeps increasing, it will be difficult to cope with it. Infrastructures must be sufficient and efficient to process the waste and revalorize it. It is also important to design all the new techniques thinking on circular economy models and anticipate the future.

4.4.2. Waste prevention

If we avoided food waste, we would save more than 841 million euros, because of fewer costs of waste treatment, there would be enough food saved to feed half a million people and approximately 3 tonnes of food waste would be avoided (Agència d'Ecologia Urbana de Barcelona, 2014). The peri-urban area of Barcelona is working on some projects such as the PERMET5 to make the most of food and to reduce food waste. It encompasses actions of the following stakeholder groups:

- Civil associations[12], must redistribute food, make diffusion on the issue and launch campaigns to collect food. This enables society to participate actively in solving the issue.
- Public administration[13] must investigate the issue, look for ways to prevent it, and improve the collecting schemes. They should also launch a unique policy on food waste for companies and provide solutions and workshops on the issue for society.
- Companies[14] must prevent and minimize food waste and redistribute the one they generate.

[12] Banc Aliments, Creu Roja, Plataforma compartim els aliments, others.
[13] Agència Residus CAt, town halls of the villages, Diputació de Barcelona, Generalitat de Catalunya, AMB.
[14] AECOC, Mercabarna, agricultural companies.

All in all, food waste takes part in all the food chain, so agriculture, industry, transport, restoration, commerce, and households have to be considered when willing to deal with the issue.

5. Specifications of the circular business model

For a deeper understanding of the circular business model, it is necessary to determine each step of the supply chain in which the company would have a presence. It is important to remember that the business model would only work around the peri-urban area of Barcelona, at least in the beginning. Expansion to other regions could be considered in the future.

The legal form adopted would be an S.L. because of its simplicity in terms of bureaucratic procedures, the low minimum share capital required (3,000€), and the liability against creditors which is limited to the share capital and assets in the name of the company.

To get financing for the company, crowdfunding would be first carried on. Family and friends would also help in the first steps. It is also important to try to look for grants and support from the EU government. For instance, they are planning to launch €100 million through the circular bioeconomy thematic investment platform. As a next step, the company could raise money with venture capital. For example, partnering with *Blisce,* a venture capital fund that promotes eco-friendly companies.

As mentioned when presenting the idea and the strategy, two interconnected cycles are present in the circular business model: the production of food preservatives and compost or organic fertilizers. Both of them are analyzed in-depth below.

5.1. Food preservatives

5.1.1. Production of raw materials

Raw materials of the company will be already produced and will be food which is going to be thrown away. The main reasons are either because it is not attractive, is soon to expire, are food by-products or it is just not accepted by the market. In this step, we have 3 sources of collaborators. On the one hand, farms. Among the area, *L'Ortiga, Central Parc del Baix Llobregat SCCL, Conreu Sereny* and *Tarpuna* are agricultural cooperatives that could provide with their food they do not want. On the second hand, food transformers (possible partnerships are stated in the Barcelona city analysis). Lastly, commerces, which could be specialized ecological shops, fruit shops, or markets and where products would be sold afterward. It is interesting to note that there is already one online platform called *ResiduRecurs*[15] which basically connects sellers of materials that have been already used and that do not need anymore, together with buyers who need the material and do want to make the most

[15] Webpage link: <https://www.residuorecurso.com/ca/anuncis/filtrat>

of it, not buying it new. One can find from plastic boxes to residual food waste coming from the production of processed food. To enhance the business model, the company could take advantage of this platform, although, it should not rely only on it because the presence of food waste is volatile.

5.1.2. Collection

For the collection of the raw materials, the company would have to hire its own workers. Moreover, a big van or a truck would be needed to transport the products to the storage place. So, the company would either have to buy or rent its own vehicles. For the first option, a cheap and electric second-hand vehicle would be the most suitable with the values of the company. Although one might believe that it is difficult to find a vehicle satisfying the three characteristics at the same time, it is possible. The second option corresponds to either leasing or renting an electric vehicle. Within this option, it is important that the company lengthens as much as possible the life of those vehicles, instead of changing them with the appearance of a new model. All in all, an analysis should be made to analyze whether leasing or renting an electric van would be more or less harmful to the environment rather than buying a second-hand electric van. Also, prices would have to be considered, since the company would not be able to afford high prices (at least in the initial stage of the company). Once collected, edible food loss and its by-products would have to be stored someplace. This would be done in a city placed in the peri-urban area of Barcelona, close to Barcelona city, where renting or buying buildings[16] is cheap and in a strategic place in between the different farms which are producers of the raw materials, so that all kinds of transportation costs (C02, oil…) are minimized. To run out the place, green energy will be provided by *Holaluz.*[17] They offer fair prices, so it would not entail an extra cost for the company. Materials needed for the conservation of the food would be bought second-hand. For example, refrigerated chambers nearby Barcelona can be found on the Wallapop[18] platform.

5.1.3. Transformation into new products

As previously seen in the Barcelona city analysis, the peri-urban area of Barcelona counts with two different common workshops where the transformation of the raw materials could be transformed into

[16] For most of the industrial warehouses, average selling prices were 703€/m2 in May 2022 in the AMB and an average of 4.60€/m2 for renting. For smaller establishments, the average prices of renting were 14.34€/m² in May 2022 and average selling prices were 1,749€/m². A useful link to find buildings is the following one: https://oficinesilocals.amb.cat/Indicadors Source: Metròpolis Barcelona, 2022. *Naus i Solars - Àrea metropolitana de Barcelona*. [online] Nausisolars.amb.cat. Available at: <https://nausisolars.amb.cat/Indicadors > .

[17] Founded in 2010 in Barcelona, HolaLuz company aims to live in a 100% renewable world. It offers several fares which can be customized to the wish of the consumer, supplying green energy and gas if needed. More information on its webpage: https://www.holaluz.com/ca/

[18] Wallapop is a Spanish second hand online platform which connects sellers of products and its buyers. It offers a wide range of products. Source: < https://es.wallapop.com/> , Link of second hand refrigerated chambers: <https://es.wallapop.com/app/search?keywords=frigorifico%20industrial&category_ids=13100&filters_source=search_box&latitude=41.38804&longitude=2.17001>

new products. Those are the *Ecocentral*[19] one and *Le Pain Tranquille.*[20] Both enable the production of preserved food. *Ecocentral* is a private workshop and *Le Pain Tranquille a* social workshop. Due to the nature of their work, only producing in *Le Pain Tranquille* would be possible. While producing there, only a rent would have to be paid, and machines would be shared with other companies. Although it is quite far from the city of Barcelona, if the project worked well, then the company could open its own common workshop in the city in the future.

It is also important to specify the products which the company would produce. Given the case that 45.6% of the participants in the consumption habits survey do not follow an omnivorous diet, and thus, do not eat either meat, fish or dairy, it is important to concentrate on the production of plant-based products. To make them even more inclusive, products would also be gluten-free and free of the most common allergens. Because of the ease and benefits of these food preservatives, the company would basically produce either jam, vegetable/fruit spread or soup. The raw materials used would depend on the seasonality and their availability.

After the transformation into new products, those have to be packed. To do so, single-use packaging will not be used. There are two main ideas here. The first one, using big packs in bulk, bought by the company. This initiative would enable consumers either to bring their own reused recipients to put the quantity of product that they want or to rent some of the *Bûmerang*[21] recipients that would have to be available in the shop. Although, this idea entails a problem. Preserved food would expire faster and would maybe have to be thrown away, something that does not go along with the values of the business model. The second one, using glass recipients and encouraging consumers to return them to the shops so that they can be later reused. This idea also brings some problems. Shops might not have enough space to store the returned recipients, the consumer might not really return the recipients, recipients would have to be cleaned and the collection of recipients to return them to the workshop would entail transportation costs. Those costs could be offset with the cost of having to buy new recipients.

Packaging of the products would be complemented with a removable attractive tag, so it makes the product appealing to consumers. On it, there would be the label of the certificate of ecological product

[19] Shared workshop *Ecocentral* (Hospitalet de Llobregat): their main project, Ecomenja connects little agricultors with canteens of Barcelona, providing 10,000 menus daily and ensuring food for schools is healthy, ecological and seasonal. This workshop is managed by the private company Biogrup, S.L. Source: < https://ecocentral.cat/>

[20] Shared workshop of *Le Pain Tranquille* (Premià de Mar): place for entrepreneurships, where local and small producers, cooperatives and other associations consolidate their activity. Not directly managed by any private company. Source: <http://lepaintranquille.org/>

[21] *Bûmerang* was founded in 2019 in Barcelona as a circular start-up to tackle the use of single-use plastics and achieve zero waste. It offers the renting of reusable packaging for delivery and take-away. More information on its website: < https://ca.youbumerang.com/>

of Catalonia[22] and the European[23] one. That would make the recognition of ecological products easier. Moreover, information regarding where does the product come from, which are the raw materials and how has been produced and distributed would be stated, so transparency is guaranteed.

5.1.4. Distribution system

Different types of distribution would be implemented. On the one hand, the distribution of the products from the warehouse to the different selling points would be carried with trucks, since the warehouse would not be placed exactly in Barcelona. To minimize the use of trucks, which rely on limited resources and generate C02, products would be brought in bulk to a specific point in Barcelona, where they would be taken by other distributors who would bring them into the different shops and markets. Those new distributors would be ones such as *VanAPedal*[24] ones, a sustainable company that distributes products by bike in the city of Barcelona.

5.1.5. Commerces

As previously mentioned, citizens in Barcelona buy most of their food in supermarkets. Although, when talking about fruits and vegetables, people still buy them the most in fruit shops, representing a cultural thing here in Spain. In the beginning, products would be directly sold in fruit shops, local commerce or markets which collaborate with the company providing their food by-products or soon-to-expire food.

One might think that selling, for example, jam, in a fruit shop, would be strange, but if the product was placed together with a poster stating that it has been produced with food that was about to be wasted in that shop, then that could caption people's eyes and they would prefer to buy it in comparison with others.

With the greater expansion of the model, products could be sold in supermarkets. It is also remarkable that few people buy food products online, thus, at least in the beginning, the company would only concentrate on in-person-selling. In the future, an expansion to online platforms could be analyzed.

16.9% of the people in the survey conducted, stated that they do not buy ecological products because of a lack of information. The consumer must be provided with all the necessary information of the products to enable them to make good decisions and let them change their consumption habits towards those which reduce food waste. Therefore, an informative poster would be placed, stating that those products have been produced with fruit or vegetables that could not be sold in that exact shop. Buyers,

[22]Segell del Consell Català de la Producció Agrària Ecològica.

[23] Only if requirements on <https://ec.europa.eu/info/food-farming-fisheries/farming/organic-farming/organic-production-and-products_en> were satisfied.

[24] *VanAPedal* is an eco-logistics and sustainable mobility company. Its main tasks are the transportation of goods in Barcelona and the repairment of bicycles and cargo bikes at home. Source: <https://www.vanapedal.eu/ca/>

worried about transparency and proximity of products, would be captivated by it and that might influence their purchase.

5.1.6. Recipes

This business model also has a social project. Within it, would include elderly people who are at risk of exclusion from society. They would participate by providing recipes and advice on how to prevent food waste and make the most of food. Those would be published on the online webpage of the company, which would be able to be scanned from a QR code placed on the tags of the products. In that way, the elderly would be provided with a place to communicate with each other, meet new people, and empower their knowledge.

5.1.7. Price

It is important to consider that 63.1% of the contestants in the survey conducted do not buy ecological products because of their high price. Therefore, prices must decrease. Also, 2.5% of the population in the area receives food aid, so it must be considered when setting prices. The price of the company's products sold would be determined by all the costs needed to be produced, distributed, and sold. The company's aim is not to make lots of money but to tackle food waste, climate change, and hunger. Providing a fair price, as seen in the surveys, people will be more encouraged to buy the products.

5.2. Compost or organic fertilizer

For the production of compost or organic fertilizer, different specifications will be considered. The focus will be on the collection of compost from individuals from households.

5.2.1. Production of raw materials

In this case, raw materials will be inedible food waste collected either by the different collaborators or by households. Among the survey conducted, 91% of the contestants stated that they recycle, and 93.3% stated that they do know what compost is. It was also asked whether they would like to participate in bringing their organic waste to the collection points in the shops, and 73% of them answered that they would be willing to do it[25].

5.2.2. Collection

Organic waste would be collected in some of the different fruit shops, local commerces, or shops where the company's products would be sold. To not bother them a lot, the collection would be done once a week. People would be able to dispose of their organic waste in containers placed in shops. Once the assortment had been done in the shops, distributors from *VanAPedal* would collect it and bring it to a particular point in Barcelona, where a van would bring it to the production place.

[25] It must be taken into account that already 9% of the participants in the survey are doing compost.

5.2.3. Transformation into new products

The compost or organic fertilizers would be produced in the building that the company would own/rent and that would be in a city close to Barcelona, in a strategic place near the different farms.

5.2.4. Distribution system

The organic fertilizer and the compost would be distributed by the same trucks that would go to collect the food by-products on farms, and at the same time. Therefore, they would not enhance extra journeys and would make the most of it, trying to minimize costs and environmental footprint.

5.3.5. Commerces

For those citizens who would have previously brought their food waste to shops, if they wanted it, they would also be provided with compost. For its distribution, trucks would bring it to Barcelona, where *VanAPedal* would distribute it in the different shops. To take advantage of the journey, it would be done on the same day as when picking up the organic waste.

5.2.6. Price

People bringing food waste would not have to pay for the compost, since they would be the main providers of the raw materials.

Moreover, although the idea is to not involve money for it, farms would be able to negotiate with the company, for example, exchanging compost for food by-products or providing discounts in the exchange of compost. If no agreement was reached, they would have to pay a price in order to cover transportation costs.

6. The economic viability of the model[26]

In order to make this circular business model realistic, it is necessary to guarantee that economic viability will exist in the future. We must consider all factors involving a business, such as the demand and supply of the product.

Regarding the demand, we must consider that the demand for food is everlasting, so the industry will not suffer from a decline in sales. It is expected that 80% of food will be consumed in cities by 2050. Therefore, the supply of food will have to be adapted, looking for different production methods, different sources of proteins, and dealing with resource scarcity. A circular business model for food in the city of Barcelona, as an alternative innovative model of food supply, has, therefore, a strong potential. The company, as mentioned before, will have to cooperate with different stakeholders in the different supply chain steps.

[26]This section has been influened by: C.Esposito, M.Romeu, M.Seki and I.Kim, 2022. *Circular Economy Action Plan on Prevention of food waste in the city of Barcelona.* [online]

- **Farmers** will be incentivized to do business because they would be helped with their waste collection and at the same time, they will be regenerating their soil with organic fertilizers. Moreover, they could get discounts on the company's products or even for free (in case they were giving food waste for free too).
- **Companies working on the production** of the new products would be benefited because they would be paid for their job done and they would not have to manage their food waste collection (the CE company would deal with it).
- **Distribution and logistic companies** partnered with the CE company would benefit from proximity, an aspect that can benefit them with lower expenses and more flexibility. Moreover, if the CE company was profitable, it could provide them with money to fasten the transition into sustainable practices, such as using electric transport.
- The **commerce** where the new products would be sold (fruit shops or markets), would reduce the quantity of food that they cannot sell. They would benefit from the decrease in costs of waste treatment since the CE company would manage it. Moreover, with the compost points, the word of mouth would increase and an increase in the number of customers would follow, together with an increase in its loyalty. Therefore, stronger relationships would be built. Moreover, commerce would be able to provide new products whose main characteristics would be their transparency and proximity. The CSR of the stores would be enhanced.
- **Consumers** would benefit from good quality and transparent products and would at the same time tackle food waste and climate change. Moreover, those adopting new diets would be able to consume the products without worrying about the ingredients.
- **Citizens** would mainly benefit from the creation of new jobs in order to sustain the business and also would be provided with compost if they disposed of their organic waste at one of the collection points. They would be able to learn new recipes which would have been published on the company's website and obtained by including local elderly people in the project. They would indirectly benefit from health issues, with less exposure to pollution, contamination, and pesticides, among others. Moreover, people at risk of hunger would be provided with some of the company's products and also some of the food collected which was going to be thrown away by commerce. Thus, they would be benefited with food.
- All other stakeholders related to the **food industry**, but not directly linked to our company, for example, processing companies, would benefit from the collection of their food waste, if they wanted a partnership. The food industry would also benefit from the introduction of circular practices since they could ask for advice from the company and that would encourage other companies to follow the model.

- The **environment,** present in all the steps of the supply chain, would benefit from the reduction in CO2 emissions, water eutrophication, and air pollution; and would be provided with soil regeneration. All these would be thanks to the decrease in food waste, the use of electric vehicles, and the use of green energy. Moreover, with the use of non-disposable packaging, plastic pollution would also decrease.
- Finally, the **CE company** would be benefited from lower raw material costs (use of almost expired products), low transportation costs (thanks to proximity), rent (use of common workshops to produce and only one rented/owned place to store the products), low advertising costs (word of mouth communication) and low packaging costs (consumers could bring their own recipient, use *Bûmerang* or company could reuse the packaging). Those aspects would allow the company to achieve a competitive price. Moreover, the risk of dependency on finite resources such as oil would decrease. And finally, given the fact that the food industry will last up to the infinite because there will always be food demand, the company can reduce the risk of industry disappearance.

Financing would be easier to manage thanks to the aforementioned arguments which clearly show the long-term profitability of the model and also because of the different grants that can be obtained from the government.

6.1. Business model as a source of competitive advantage

Having explained the economic viability of the model, now, one must focus on its strengths and sources of competitive advantage.

One of the most important strengths is that this circular business model is at the same time environmentally viable, socially responsible, and economically profitable, which makes it sustainable. Closing cycles would strengthen the links between stakeholders and the company, which is important to enhance good business practices. Stakeholders would receive some extra profits for something they were going to throw away, and also receive organic fertilizer, compost or food products that they could sell, so it is a good deal for them to make business with the CE company. Due to low material costs and low costs of production, the company prices would be competitive and the products would be able to play an important role in the market since they would be affordable to the whole society.

Moreover, enhancing a regenerative system throughout the compost and the organic fertilizer would provide the company with a competitive advantage. At the same time as using local and seasonal products, inducing regenerative practices which would increase traceability and food safety.
Another strength is that the business model would provide a change of paradigm to the society, they would be able to participate in tackling both food waste and climate change, issues that people nowadays value a lot. Moreover, by including elderly people in the business, the company would

benefit from important knowledge and generosity at the same time as would be including them in the society. Finally, by expanding the business model to other cities in the future, the company would be acting as an active catalyst for change.

7. Examples of a circular business model for food waste

In Catalonia, there is already one company very similar to the one that has been developing throughout the paper. It is *Fundació Espigoladors*, a non-profit organization that fights against food waste and losses, at the same time as empowering people at risk of social exclusion. Up to today, with their actions, they have recovered 2,084 tonnes of food, prevented 1,444 tonnes of Co2 emissions, saved 1,338 million liters of water, and served 6,600,531 portions of 300g of food. Moreover, they count on the commitment of 233 farmers and have carried out 1,370 awareness actions for food waste prevention (Fundació Espigoladors, 2022).

Their tasks are based on the four following ones. Firstly, with the help of volunteers, they harvest fruits and vegetables that are not suitable for the market through gleanings. Secondly, they donate to social entities most of the fruits and vegetables they collect for people that do not have enough resources to access them. Thirdly, they transform some of the collected food into preserves while providing job opportunities to people at risk of social exclusion. Lastly, they raise awareness through education, promoting a change of social consciousness to make the most of food (Fundació Espigoladors, 2022).

The third initiative is almost the same as the circular business model that has been presented. In 2018, *Espigoladors* launched the es imperfect circular brand. As stated in their manifesto, they 1)fight for the complete and fair usage of food, 2)give a second chance to fruits and vegetables rejected from the market, 3)are a circular bioeconomy, 4)promote natural, healthy, high-quality food, 5)defend and support local farmers and local products, 6)support a transformation of the agri-food system, and finally, 7)want to inspire an attitude towards life characterized by three words: imperfect, conscious and sustainable (Fundació Espigoladors, 2022).

The specifications of their business model are provided following. Their raw materials, being fruits and vegetables rejected from the commercial circuit, are taken from farms, especially of the Baix Llobregat Agricultural Park. They have their workshop in the neighborhood of Sant Cosme in El Prat Llobregat, also known as Central Kitchen, where people at risk of social exclusion produce plant-based preserved food such as jam, pâtés, and sauces. They sell their products in stores, hotels, restaurants, and even online (Fundació Espigoladors, 2022).

8. Conclusions

It is clear that the food industry has to change, especially in cities, where supply will not be able to meet the demand in the future. The main reasons why a linear food system is harmful to the environment and not sustainable in the long term and an explanation of the impacts that food losses and waste do have on society, the economy, and climate change, have been stated in the introduction of the paper. Definitely, a sustainable circular business model for food waste would help to tackle those problems in the industry. The values of the company have not been stated directly, although one could get an idea of them throughout the paper. The main pillar of the company is circularity. Indeed, sustainable circularity, since it would have both a restorative and regenerative design, and is willing to gradually decouple growth from the consumption of finite resources. Thus, the company would try to avoid the use of first-hand products and extend the product's lifespan and maximize their use. Moreover, the company would put people and the planet first, empowering local communities, dealing with hunger, and taking care of the environment. The company would be committed to the Sustainable Development Goals of no hunger, good health, decent work and economic growth, reduced inequalities, sustainable cities and communities, responsible consumption and production, and climate action.

All in all, the main key strategies of the project are related to the following.

1. **Local and sustainable production** is essential to achieve a sustainable circular business model. Nowadays the distance between production and consumption is increasing, and food chains need many resources for distribution, difficulting its traceability. Moreover, intensive practices and the use of a linear economy system damage the environment. The business model presented would rely on short cycles and sustainable practices which would reduce those negative aspects. For instance, the production of raw materials in the peri-urban area of Barcelona, and the use of common workshops, among others.
2. **Regeneration of the environment**, with the creation of compost or organic fertilizer. To do so, individuals would have to participate by providing organic waste which would be supplied mostly to farmers and individuals who wanted it. In the survey conducted, 17.97% of the contestants stated that they do not want to do compost. The profile of those who do not want to do it has been analyzed. They usually buy food in supermarkets and 75% of them buy fruit and vegetables in fruit shops or markets. Also, none of them buys food online. Therefore, it is not the case that they would not want to do compost because they do not usually interact in places where collection points would be found. All of them recycle, so it is not the case that they would have to make an extra effort to separate organic waste. Indeed, all people who do not recycle stated that they would be willing to do compost in the future, so, recycling habits in the present are not necessarily a

reason for not wanting to do compost. Also, among those who did not know what compost is, after having read its definition, four stated they would like to do it and only two did not want to. Those are optimistic data since it means that the population is willing to change their habits towards more circular and sustainable ones.

3. It is important to encourage consumers to adopt **sustainable consumption practices**. Consumers are the ones who determine the supply. Therefore, they are key agents to improve the overall food system and make it circular and sustainable. The business would offer educational resources on its webpage, so society has the answer on how to attain a healthy and sustainable diet so they can make the best purchasing decisions.

   In the survey, 56.17% of the contestants stated that they never take into consideration the environmental footprint when buying. Although this data is not allied to the business model, the positive news is that all contestants stated they are disposed to eat more ecological products in the future. So, it is favorable for the economic viability of the model. Among those already buying ecological products, the main reasons for buying them over conventional ones are healthy reasons (68.6%) and environmental reasons (25.5%), so it is clear that people are still not very informed about the consequences that the food industry has on the environment.
4. **Efficient distribution and logistics** are necessary to enforce the main practices of the business. With the globalization of food production, new consumption habits, and the rise of online commerce, distribution systems are very complex and cause a high cost to the environment and health of citizens. Employing systems such as blockchain would help with traceability, the supply chain would be more efficient and short, and would cope with those issues. Also, although the distribution system stated in the specifications of the paper is already the most sustainable and efficient it can be, it could be improved with shared distribution systems with other companies.
5. **Circular packaging** is necessary to not generate extra waste, make the most of available resources, and close loops. As has been stated in the paper, the use of non-disposable packaging would be avoided. All in all, the company could buy second-hand glass jars to put the jam and encourage consumers to bring them back into the shop so circularity is maintained.
6. **Tackle food waste and loss.** In the survey, 39.3% of the respondents were not aware of the quantity of food waste and loss in Catalonia. 94.4% of them stated that they only waste between 0-25% of the food they buy, being the main reasons: poor planning or not proper conservation. Although it does not seem like the worst scenario, one has to keep in mind that the survey is not representative enough and that raising awareness on the topic is necessary to tackle it.
7. **Preserve food waste and loss in its highest value** throughout circular practices. It is evident that the food industry is inefficient due to the high index of food waste and loss, the generation of packaging waste, and the use of undervalued resources. Within the creation of the company, new

platforms and networks for redistribution of food waste and loss would be created and new products would be created with the revalorization of food waste. The greatest achievement of the company would be that stakeholders involved in the food industry questioned their practices and tried to look for more sustainable and socially responsible ones. Indeed, it is necessary that apart from the commerce (who would already be partners of the company), restoration or school canteens, which are also main contributors to food waste, changed their practices.

To analyze whether the implementation of the project would be viable or not in the area and to make specifications of the business model, a study of the peri-urban area of Barcelona has been carried out, following the Cities and Circular Economy for Food, city analysis instructions provided by the Ellen MacArthur Foundation. The main highlights of the study can be found in the paper and, based on the results, it would be coherent to launch the project in Barcelona. To analyze people's consumption habits, a survey was conducted. Although it is not representative enough of the population, it has been useful to extract some results and conclusions. Moreover, reasons sustaining the economic viability of the project have been exposed.

To end the present thesis, alternatives to the current food system as the one presented seem viable and will have an important role in society, the environment, and the economy. *Espigoladors*, with their circular brand *es im-perfect,* are already tackling food waste and loss in Catalonia and show that the proposed business model would be viable in Barcelona. It would have been interesting to organize an interview with them since they would have provided more information about their business. For instance, questions regarding the distribution of their products, the decisions on the packaging, or which are the main challenges they have to deal with and have already faced are interesting unknowns. In the end, the company's functioning would be quite different from *es im-perfect* one: Farmers and companies would provide the food already collected and the company would pay for it (*es im-perfect*, works with volunteers to realize the gleanings). To tackle the risk of social exclusion, the proposed company would empower elderly people (*es im-perfect* production workers are at risk of social exclusion). The proposed company could also try to implement those strategies. Also, it could be the case that the distribution system of the proposed company was more sustainable (no information on the one of *es im-perfect* was found).

All in all, food waste is such a big problem that both *es im-perfect* and the proposed business model could work in the same market and could develop synergies to work together and exploit their best practices, such as the regeneration of nature with either compost or organic fertilizer.

9. Resources

- Food and Agriculture Organization of the United Nations, 2011. *Global food losses and food waste Extent, causes and prevention.*. [online]
- Fundación Forum Ambiental, 2017. *Sector agroalimentario. Estrategias para un mundo agrario y una industria agroalimentaria más circulares.* [online]
- Ellen MacArthur Foundation, 2019. *Cities and Circular Economy for Food*. [online]
- Arsenault, C., 2014. *Only 60 Years of Farming Left If Soil Degradation Continues*. [online]
- ARC, 2019. *Datos de residuos en Cataluña*. [online]
- Poore, J and Nemecek, T., 2018. *Reducing food's environmental impacts through producers and consumers. Science, 360(6392), 987-992.* [online]
- Sauve, G., & Van Acker, K, 2020. *The environmental impacts of municipal solid waste landfills in Europe: A life cycle assessment of proper reference cases to support decision making*. [online]
- Ellen MacArthur, 2022. *Eliminating food waste*. [online]
- Ellen Mac Arthur, 2022. *Regenerative food production*. [online]
- Barcelona Activa, 2020. *Principales indicadores económicos del área de Barcelona*. [online]
- Alimentació Sostenible, 2022. *Capital Mundial de l'Alimentació Sostenible 2021*. [online]
- AMB, 2022. *Localización y usos del suelo*. [online]
- Barcelona opportunity, 2022. *Una metròpolis verda i saludable*. [online]
- Departament d'Estadística i Difusió de Dades, 2021. *La Población de Barcelona Lectura del Padrón Municipal de Habitantes a 01/01/2021 Síntesis de resultados*. Barcelona: Oficina Municipal de Dades. [online]
- Institut Cerdà, 2017. *La dimensió econòmica del sistema alimentari a l'àrea metropolitana de Barcelona: abast, reptes i oportunitats.*. AMB, Desenvolupament social i econòmic. [online]
- REDEL. 2020. *El PIB per cápita en la metrópolis de Barcelona es un 23% superior al de la media de la UE - REDEL*. [online]
- Alimentació Metropolitana, 2022. *Producció*. [online]
- Associació Arran de Terra, 2018. *El sistema alimentari de Collserola. Reptes i potencialitats per a la Transició Agroecològica.*. Consorci del Parc Natural de la Serra de Collserola. [online]
- Agència Metropolitana de Desenvolupament Econòmic, 2019. *La producció agrària a la metròpolis de Barcelona representa només el 2 % del consum total*. [online]
- Institut Cerdà, 2019. Disseny d'una proposta d'observatori del sistema alimentari metropolità de Barcelona de l'agència Metropolitana de Desenvolupament Econòmic de l'AMB. [online]
- Viladomat, R., 2021. *Quinze obradors i escorxadors de transformació agroalimentària a la demarcació de Barcelona son equipaments compartits*. [online]

- DIBA, 2019. *Hàbits de consum i compra de Barcelona. Infografia.*. [online]
- Roca Torrent, A.; Muñiz, S.; Balbás Alonso, D, 2021. *Taula d´Agricultura metropolitana. Área Metropolitana de Barcelona: Barcelona.* [online]
- CCPAE, 2020. *Baròmetre 2020 de Percepció i Consum dels Aliments Ecològics*. [online]
- INÈDIT, 2017. *Tendències d'ecoinnovació en el sector agroalimentari*. [online]
- IDESCAT, 2019. *Idescat. Indicadors territorials de risc de pobresa i exclusió social. Indicadors relatius a la protecció social. 2/2. Catalunya. 2019*. [online]
- Ajuntament de Barcelona, 2021. *Més productes de proximitat i ecològics als mercats de Barcelona.* [online]
- AMB, 2022. *Residus*. [online] Amb.cat.
- ARC, 2021. *Principals magnituds 2020 de la gestió de residus municipals.*Generalitat de Catalunya. [online]
- OMD, 2021. *Anuari Estadístic de la Ciutat de Barcelona 2021*. [online]
- Departament d'Estadística i Difusió de Dades, 2020. *Residus municipals recollits segons destinació (%)*. [online]
- AMB, 2022. *Infraestructures de gestió de residus*. [online]
- Ajuntament de Barcelona, 2022. *Neteja i Residus Ecologia, Urbanisme, Infraestructures i Mobilitat*. [online]
- AMB, 2022. *Prevenció*. [online]
- Agència d'Ecologia Urbana de Barcelona, 2014. *APROFITAR ALIMENTS, PREVENIR RESIDUS Guia d'acció local. L'experiència de la Botiga Solidària de Cornellà de Llobregat*. [online]
- Mercabarna.es, 2019. *Mercabarna, la ciudad que te alimenta. Memoria de sostenibilidad*. [online]
- Fundació Espigoladors, 2022. Espigoladors | *Lluitem per l'aprofitament alimentari*. [online]

10. Annex

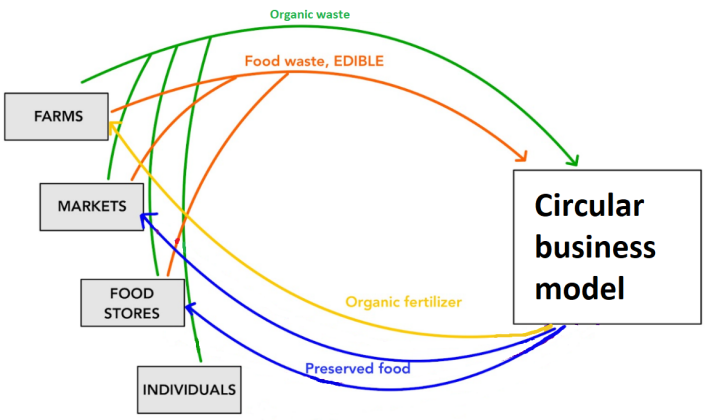

Figure 3: Circular business model cycle. Source: Own elaboration.

Barcelona city analysis

As mentioned in the project, this analysis is based on the city analysis guide of the Ellen Macarthur Foundation[27]. It has been adapted for the purpose of this project, and not all the steps will be analyzed.

1. Understanding the city archetype and surrounding region

Barcelona is the second most populated city in Spain. In 2010, its surrounding cities joined together and created the well-known Àrea Metropolitana de Barcelona. It is formed of 36 cities and according to Eurostat, it is the 8th most populated area in Europe. It constituted 43% of the overall population in Catalonia and 2% of its surface in 2021. It is located in a strategic position in the south of Europe, on the shores of the Mediterranean sea and connects Spain with the rest of the continent. Thanks to its big territory, it includes the agricultural areas of the Llobregat delta, the large green areas of the massifs of Garraf and Collserola, the Marina mountain chain, the Besós and Llobregat rivers, and the whole urbanized areas which constitute 48% of the territory (AMB, 2022).

In ***Table a***, one can find the information required by the Ellen MacArthur Foundation. The population growth has been stable since 2010 with a 0.23% growth and a small peak in 2019 (Departament d'Estadística i Difusió de Dades, 2021). Moreover, according to Estadístiques Diputació de Barcelona, in 2015, tourists represented 23% of food expenditure in the city.

It is also important to remark that Barcelona's GDP is 34.7% of the overall GDP in Catalonia and in 2015 was 23% higher than the overall GDP x capita of Europe and it has an increasing trend (REDEL, 2020). It is mainly obtained by the service sector, specifically, 89.1% obtained from commerce, hospitality, transport, and information and communication industries (Observatori Econòmic Metropolità, 2021). It is relevant to keep in mind that according to the basic economic indicators of the Area Metropolitana of Barcelona of 2020, only 0.1% of the population works in the agricultural sector in the area (Barcelona Activa, 2020).

Data required to determine archetype	
City population	1,636,732 inhabitants
Peri-urban population	3,719,096 inhabitants
City density	16,149.3 inhabitants/km2
City GDP	77,844 million euros
Peri-urban area GDP	124,687 million euros
Major economic driver in the city	Services
Major economic driver in the peri-urban area	Services

Table a: Data required to determine the archetype by Ellen MacArthur Foundation. Source: idescat.cat.

[27]Ellen MacArthur Foundation, 2019. Cities and Circular Economy for Food, city analysis instructions. Source: <https://emf.thirdlight.com/link/mw02glgs335s-xmt5kq/@/preview/1?o >

2. Assess urban and peri-urban food production

The aim of this step is to make an analysis of the local food production in the peri-urban area of Barcelona including areas, quantities, and methods of production. It is essential to cover both primary production and food processing to look for synergies between the industries.

Food production

Being the peri-urban area of Barcelona quite urbanized, the territory for food production only corresponds to 6% of it, but there is still room for agricultural production with an important potential. Each year, the total agricultural production of the area is 38,752 tonnes and it is basically based on green vegetables (72%) and fruit (24%). The production is mostly concentrated in the area of "el Parc Agrari del Baix Llobregat" (2,264 ha for agriculture) and also extended to Collserola (413.6 ha for agriculture) (Alimentació Metropolitana, 2022).

With the increased tendency for sustainability and healthier food, an increment in the number of urban gardens has followed, occupying empty spaces in cities to produce food. In Barcelona, urban gardens have reached almost 500. Counting urban gardens and private agriculture, the territory for food production increases up to 8.5% (Alimentació Metropolitana, 2022).

Here below, an analysis of the main two parks of the peri-urban area of Barcelona is presented.[28]

-Baix Llobregat agricultural park[29]

Thanks to its good climate conditions and enough water supply, it is an area that generates high productive, ecological and social value. Therefore, most of the food companies are found in this area. Yearly, 22,663 tonnes of agricultural products are produced, being 89% green vegetables and most of the land destined to produce artichokes (405ha) (Barcelona opportunity, 2022).

Among its territory, 45% of the land is owned and the remaining 55% is leased. The commercialization of its products is basically done throughout *Mercabarna* (70%), the remaining is carried out through direct channels such as markets or cooperatives. The most important agricultural companies found in Baix Llobregat are *Fruit Sa2pe*, *Blecamp*, *Fruitcamp*, *Brot Nou* and *Canillo,* (Alimentació Metropolitana, 2022).

-Collserola mountain chain agricultural park

[28] The ones discarded are due to the fact that most of its agricultural territory is threatened by the urbanization pressure and due to its viability challenges, it is not subject to high profitability.

[29]Villages included in the area: Castelldefels, Cornellà de Ll., Pallejà, Papiol, Molins de Rei, Sant Vicenç dels Horts, Santa Coloma de Cervelló, Sant Feliu de Llobregat, Sant Joan Despí, El Prat de Ll., Gavà, Viladecans, Sant Boi de Ll.

This park is not as productive as the Baix Llobregat one mainly because the dimension of its farms is smaller. Although, the products are of high quality and tend to be ecologic. Fruit trees and green vegetables are the most present products, followed by vineyards and olive trees.

Since 2018, with the launch of the Alimentem Collserola! project, production in the area is moving towards more sustainable and fair practices. Moreover, since 2015, tomatoes, cherries, wine, and tangerines produced in the are distributed with a certificate of quality of the area. There also exists the Arrela't project which aims to provide support to farmers in Collserola when planning and producing ecological agricultural products. Important local farmers found in the are are the following: *Collserola Pagesa, Pagesia no organitzada, Can Pujades, L'Ortiga, Collserola Iniciatives, Slow Food and l'Espigall* (Associació Arran de Terra, 2018).

Food processing

Going more in-depth on the city of Barcelona, according to the Agència Metropolitana de Desenvolupament Econòmic 38,752 tonnes of food are produced yearly in the city. There are 33,591 companies working in the food industry either in the primary sector (704 companies), in the commerce sector (13,873), in the restoration industry (17,959), and others (1,055) (Institut Cerdà, 2019). Moreover, 170,259 tonnes of edible waste are recycled yearly (Agència Metropolitana de Desenvolupament Econòmic, 2019).

Remarkable companies which deal with work with fruits and vegetables are *Cultivar, CMR, Bargosa, Hnos Fernandez Lopez, Colofruit, Eurobanan, Torribas, Germans Barri, and Patatas Bone*t.

According to el Consell Català de la Producció Agrària Ecològica (CCPAE), among all the 9 municipalities that constitute the Collserola mountain chain, there are 108 companies that work in the ecological food production industry. Of those, 75% are found in Barcelona and produce 21 different types of products. Most processed products in the area are oil and fats (Associació Arran de Terra, 2018).

-Common workshops in the AMB[30]

Created by the Smart Rural Project to incentivize agricultural local practices and create synergies between producers and consumers, common workshops deal with the elaboration and transformation of agricultural products through traditional and artisanal practices, making the most of the surpluses of production and shortening the cycle of products by diversifying the channels of distribution (Viladomat, R., 2021). Those workshops count on the necessary machinery to enhance the production and also allow their collaborators to bring their own materials.

[30] Webpage to find common workshops: < https://obradorscompartits.cat/?l=ca&lat=41.74263&lon=1.62323&zoom=9>

Among the peri-urban area of Barcelona, one can find the shared workshop of *Le Pain Tranquille* (Premià de Mar) and the shared workshop *Ecocentral* (Hospitalet de Llobregat).

3. Assess urban food consumption

Food types and quantities

Food consumption can be either domestic or outside the home. A total of 6,368,536,542 and 2,133,459,742 euros of food consumption were spent respectively in 2019. Moreover, tourists spent 1,290,384,735 euros (Institut Cerdà, 2019). No information regarding the food types was found.

Logistics and food distribution

Mercabarna partners with more than 700 companies related to the food industry. It is one of the principal food clusters of southwest Europe, mainly for its strategic position, close to Barcelona city. 18.7% of the fruit and vegetables sold in *Mercabarna* come from Catalonia, two-thirds of it produced in the Àrea Metropolitana de Barcelona (Institut Cerdà, 2017).

We can find different channels of food distribution among the peri-urban area of Barcelona.

-Organized distribution: supermarkets, hypermarkets and others. *Mercadona* has the biggest market share (15.9%).

-Independent distribution such as fruit chains, specialized shops such as ecological food, zero waste shops and others.

-Local markets. 99 markets can be found in the peri-urban area, 40% are located in Barcelona. Most of the food in markets is supplied throughout *Mercabarna* (41.70% in 2011).

-Farmer's market and itinerant markets (use of detachable stalls). In the Àrea Metropolitana de Barcelona, 16 and 6 can be found respectively. Among those, 46% say they offer both local and ecological products.

There are other food distributors such as e-commerce and food delivery companies, restaurants and canteens but those are not analyzed since they are not linked with the business model.

Consumption habits

The analysis of the consumption and purchasing habits is important to observe the different profiles of the consumers, their preferences, purchasing habits and motivations to buy. Therefore, it is important to understand the demand.

A survey[31] has been conducted in order to analyze the consumption habits in the city of Barcelona. The sample size has been smaller than expected, approximately 100 respondents have answered the

[31] When providing data from the survey, one must consider that the majority of contestants are women (52.8%), between 16 and 34 years old (87.6%) and are students (49.4%). Therefore, the sample is not representative enough of the population in Barcelona and therefore, it will only be considered to complement the studies realized in Barcelona.

questionnaire. Because of it, the analysis will be carried on with the information collected from the 2020 barometer, which made a survey of the Catalan population, being most of the participants in the survey were from Barcelona (74%), so it is perfect to extract conclusions for this project. Moreover, there is also information taken from the infographics on the consumption habits of food in Barcelona city.[32]

Further analysis of the consumption of ecological food can be found in the main project.

-Profile of the buyer

Today's consumers have little time to either buy or cook food and thus they tend to share housework, involving shopping, with their partners. They are constantly connected with their internet devices. Thus, they can always know which products are offered and ask for information at any time of the day. The consumer wants a diversity of high-quality products, wants pickup points and also home delivery of products (Roca Torrent, A.; Muñiz, S.; Balbás Alonso, D, 2021).

According to the infographics on the consumption habits of food in Barcelona city, we can distinguish between different types of buyers in the Catalan market. Based on gender, women are the main buyers (54.9%). Based on age, people between 35 and 49 years old (57.50%) are the ones who buy the most, followed by the range of 16 to 34 years (41.10%). Moreover, among those who buy, 81.40% work. Finally, regarding the purchasing responsibility, 53.90% do it in exclusivity instead of sharing it with their partner (DIBA, 2019).

-Where do they buy food?

When talking about fresh food[33], 47% of the population in Barcelona buy it in the supermarkets and 35.80% buy it in local shops in the neighborhood and 4.50% buy it in markets. It is interesting to know that just 0.70% of people buy fresh products directly from the farmer[34] (DIBA, 2019). When talking about other types of food[35], 68.81% of the population buy it in supermarkets and just a 12.70% in shops in the neighborhood, followed by hypermarkets with a 12.01% (DIBA, 2019).

Within the own survey conducted, 33.7% of the contestants stated that they usually buy online and 20% of them also buy food products (own survey, 2022).

-Cost of a basket

[32] DIBA, 2019. *Hàbits de consum i compra de Barcelona. Infografia.*. [online] Diba.cat. Available at: <https://www.diba.cat/documents/153833/294586549/infografia_barcelona19.pdf/7146df8b-8fc7-4149-9559-4d948cbb0850>

[33] A question on the survey conducted, asked where did they buy fruits and vegetables (considered fresh products), 48.3% stated that they buy them in fruit and vegetable shops, 31.5% buy them in supermarkets and 11.2% in markets.

[34] In the survey elaborated, 5.6% of the respondents stated they buy directly from the farmer, so in comparison, the amount is much higher.

[35] When talking about other types of food, 84.3% of the participants in the survey stated they buy it in supermarkets. hypermarkets, neighborhood shops and specialized shops obtained similar results.

An approximation of the average annual budget allocated to food consumption is said to be 1,966 euros and the cost of a monthly basic basket, is 192.84[36] euros. This enables us to understand the purchasing power of the citizens in the area. Considering this data, citizens are not able to afford a basket of higher quality rather than the basic one, since, with this budget, they would only have 163.83 euros to spend monthly (Institut Cerdà, 2019). Therefore, one may conclude that the purchasing power of the population on average is not high. Indeed, already an average of 2.52%[37] of the population in the AMB in 2019 and 1.9% of total the population in Barcelona city received food from the charity (IDESCAT, 2019).

-Preferences

According to a survey done by the Generalitat, Catalan consumers prioritize quality over price and its third main requirement is the establishment[38]. Gender, age and level of studies do have a relationship on bought products, results show that women and older people give the most importance to quality whereas young people value price the most (CCPAE, 2020).

Moreover, when doing the buying process[39], 78.8% take into account the seasonality of the products, 66.9% consider the number of conservants and colorants and 65.4% take into account the proximity of the products. Being produced carefully with the environment, caring for the animals, cheap or artisanal are less taken into account (CCPAE, 2020).

-Main concerns

What the consumer worries the most is about food security, transparency and sustainability. On the one hand, it is important to offer natural healthy products without preservatives or additives, also known as ecological products. On the other hand, informing consumers about the effects each product has on health, where does each product come from and which are their ingredients, among others, will help the consumer to make decisions. Finally, it is important to offer local and fresh products, to shorten the food cycle, decrease transportation costs and give the chance to the consumer to cooperate throughout its neighborhood, such as contributing to an urban garden and therefore, contributing sustainability (INÈDIT, 2017).

-New diets

[36] Although it must be taken into account that the basket cost in 2018 is considered to be expensive and that for instance in 2016 was 139 euros (Institut Cerdà, 2019).

[37] Data of 10 villages of the peri-urban area was missing. An average of the other ones has been done.

[38] Based on the survey done, 67.4% of the contestants value the offer of cheap products when buying, 65.2% value the offer of healthy products, 48.3% the offer of tasteful products and 38.2%, products from proximity. Other aspects, such as fair commerce, organic products, establishment to buy the product, brand or packaging were voted on the survey (stated by order of preference).

[39] In the survey conducted, 78.65% of the buyers always or usually consider the price of the products (cheaper ones) one buying, 66.29% of buyers consider the seasonality of the products and both quantity of preservatives and colorants and proximity are considered by 57.30% each one. The factor least taken into account when buying is artisanal production, which is never or rarely considered by 69.66% of the respondents.

The penetration of new consumption habits such as veganism, vegetarianism, flexitarianism, and real fodder, among others, is increasing worldwide due to the concerns about the ethics of animal rights and the environmental impact other diets have on the planet. Companies are obliged to diversify their offer, providing substitutes and using new technologies. No data on the percentage of the population following this new diet is available within Barcelona's periurban area. Although within the survey conducted, 56.2% of the respondents stated that they follow an omnivorous diet, and the rest follow different diets (own survey, 2022).

4. Determine urban organic waste and food by-product streams

Waste flows

Total waste in the city of Barcelona and its peri-urban area was 1,427,704 tonnes in 2020 and represented 1.17 kg/hab/day of waste. In 2020, 142,935 tonnes of organic waste collected separately in the peri-urban area of Barcelona came from residential sources, 11,900 tonnes came from large generators and 29,450 tonnes came from natural/vegetal sources (AMB, 2022).

According to the Agència de Residus de Catalunya, among the 3.74 million tonnes of food consumed in Catalonia each year, 1.183 million tonnes are residual food waste and 260,000 tonnes are edible food which is thrown away. Being approximately 35 kg of food per capita each year and thus 95 grams per capita each day. Among its sources, 58% come from households, 16% from restoration and 26% come from commerce (Institut Cerdà, 2017).

-Collection scheme

In Catalonia, there is a selective collection system that separates each type of waste (glass, paper, plastic, organic, and rest). In 2020, 1.8 million tonnes of waste were collected separately (45.9% of the total waste). It is important to get a selective collection of high quality because when waste is not separated correctly it affects the efficiency of the recycling process. In 2020, the organic waste was the one with the highest amount of improper material, 12% of the waste was not separated properly (ARC, 2021).

Within the selective collection of waste, 172,385 tonnes of organic waste were collected in the peri-urban area of Barcelona. Representing 43.4% of all the waste collected selectively, taking into account glass, paper, and plastic (AMB, 2022). In Barcelona, the selective collection system has increased from 11.1% in 2000 to 39.5 % in 2020 (OMD, 2021). Representing 63.5% of it from residential sources.

-Treatment type and outputs

The treatment of waste in the peri-urban area of Barcelona has changed throughout the years. There has been a sharp decrease in depositing and energy conversion and composting has remained similar.

Moreover, there has been an increase in biological mechanical treatment and a slight increase in recycling. In 2020, 60.6% of the treatment of waste was carried on through biological mechanical treatment, 25.3% recycling, 12.1% composting, 1.6% depositing, and 0.3% converting into energy. In 2020, in Barcelona, 59.1% of the waste was managed with the biological mechanical treatment and 37.9% throughout the waste material recovery system (Departament d'Estadística i Difusió de Dades, 2020).

There are several installations destined to manage the treatment of the several wastes in the peri-urban area of Barcelona. In 2022, we can find 12 plants (AMB, 2022). The treatment of Barcelona's organic waste is done in the ecopark of Barcelona, the compost plant in Torrelles de Llobregat, in the compost plant of Sant Cugat del Vallès and in the ecoparc of Montcada i Reixac (Institut Cerdà, 2017). In the eco-parks, a biological and mechanical treatment to manage organic waste is applied. From this treatment, it gets compost, biogas, and recoverable materials such as packaging (Ajuntament de Barcelona, 2022).

Waste prevention

The periurban area of Barcelona has launched some campaigns in order to prevent waste and thus minimize the use of raw materials. Those projects encourage the reduction of waste and the reutilization of products. They are based on the use of second-hand products, the reduction of single-use plastics and lastly and most important for this project, making the most of food (AMB, 2022).

The PERMET25 project establishes actions to make the most of food and to reduce its waste up to 50% in comparison to 2010 (AMB, 2022).

Actions[40]

One of the main actions of this project is to proportionate economic aid to encourage university research groups to investigate the prevention of waste. Another action is to allow villages to act on behalf of their food waste, providing them with guides to make the most of food. Last but not least, to enable the society to participate actively in solving the problem, the peri-urban area of Barcelona is launching two types of initiatives. On the one hand, cooking workshops for making the most of food (impulsed by the program Reparat Millor Que Nou). On the other hand, the diffusion of information stands on fairs, to make people realize how important it is to deal with the issue of food waste and to provide them with easy solutions[41] on how they can prevent it. (AMB,2022).

[40] Map of the different initiatives on food waste prevention:
<https://aprofitemelsaliments.org/mapa-diniciatives-per-laprofitament-dels-aliments/ >

[41] Those can be either planning the shopping, improving the storing, ways to conserve food or recipes to use edible food waste.