The PRIMA programme is supported under Horizon 2020 the European Union's Framework Programme for Research and Innovation

SUSTAvianFEED

PRIMA
IN THE MEDITERRANEAN AREA

Handbook: Guide to build a circular economy business in the agri-food sector

Key Exploitation Result 9: Circular Economy Business Model for the adoption of project approach

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1. Handbook: Guide to build a circular economy business in the agri-food sector

1.1 Introduction

This guide is intended for entrepreneurs, farmers, livestock producers and agri-food professionals who want to transform their activities toward a more sustainable model. It is based on the approach of the SUSTAvianFEED project and clearly presents how to apply circular economy principles step-by-step. At the end, includes Murcia's Region real case study.

1.2 What is the Circular Economy and Why is it Important?

The circular economy is a model of production and consumption that promotes reusing, repairing, refurbishing and recycling existing materials and products for as long as possible. Unlike the traditional linear model ('take-make-use-dispose'), the circular economy transforms waste into resources.

In the agri-food sector, this model allows agricultural and livestock by-products to be turned into fertilizers, energy, or new products. It also promotes efficient use of water and energy, helping reduce environmental impact and increase profitability.

For example, pruning residues can become compost, manure can generate biogas, and fruit and vegetable waste can feed insects later used as animal feed.

1.3 Step-by-Step: Designing Your Circular Business Model

To transform an agri-food business toward circularity, it's key to follow a series of structured stages.

Step 1: Initial Diagnosis

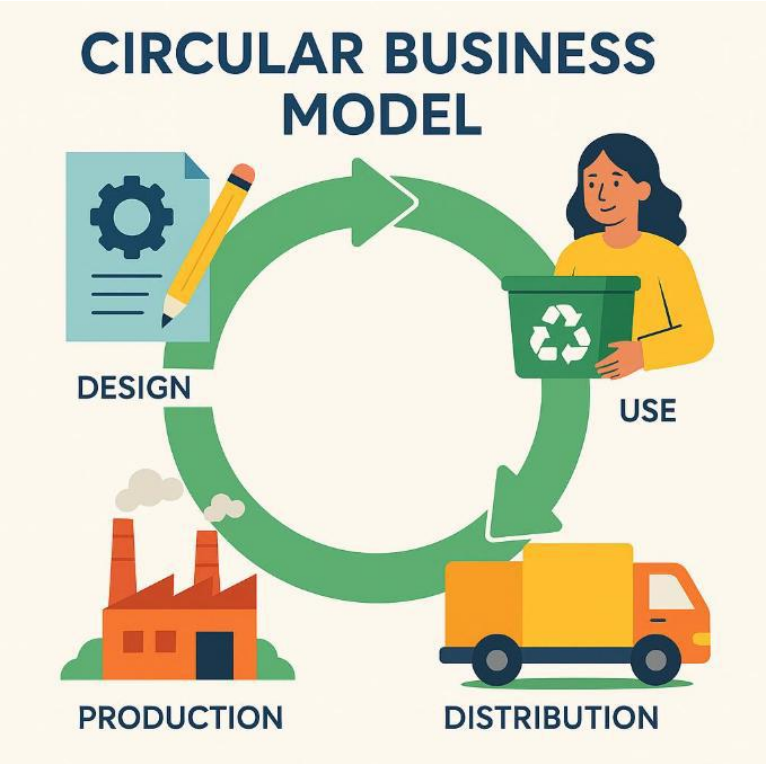
Identify your inputs (water, fertilizers, feed, energy) and outputs (organic waste, manure, by-products). List the most consumed resources and the types of waste you generate, and explore which could be reused or recovered.

Step 2: Identify Circular Opportunities

Explore how to modify your processes to close resource loops. Can you reuse manure as fertilizer? Feed animals with by-products? Use crop residues for compost or energy generation?

Step 3: Design Your Model

Use tools like the Circular Economy Business Model Canvas (CEBM Canvas) to define your circular value proposition, key partners, revenue streams and how to deliver sustainable value.

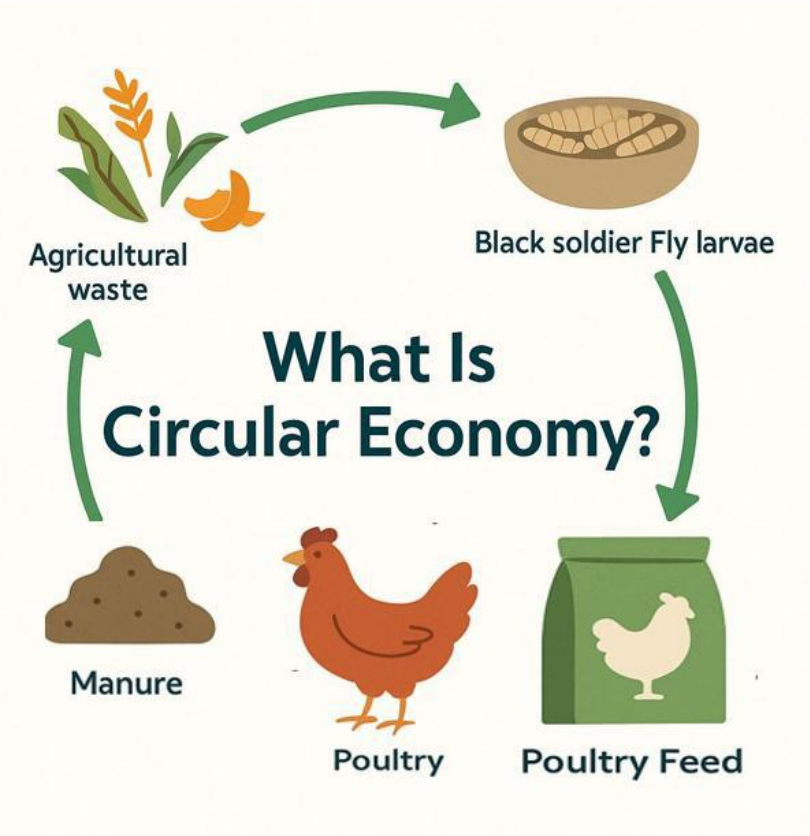


1.4 Practical Case Study: The Murcia Circular Model

Murcia (Spain) is a region with strong agricultural and livestock production, making it ideal for circular approaches. The SUSTAvianFEED project showed how agricultural waste (like vegetable residues) can be used to feed Black Soldier Fly larvae, which are later processed into protein-rich animal feed. Poultry manure is then composted and used as organic fertilizer for crops.

This model closes multiple loops: reduces waste, replaces imported soy-based feed, improves soil health, and lowers greenhouse gas emissions.

Such integration requires cooperation between producers, processors and technology partners but can begin on a small scale by a single farmer or entrepreneur.



1.5 Tools and Resources for Circular Business Design

Designing a circular model is easier with digital tools and structured methodologies.

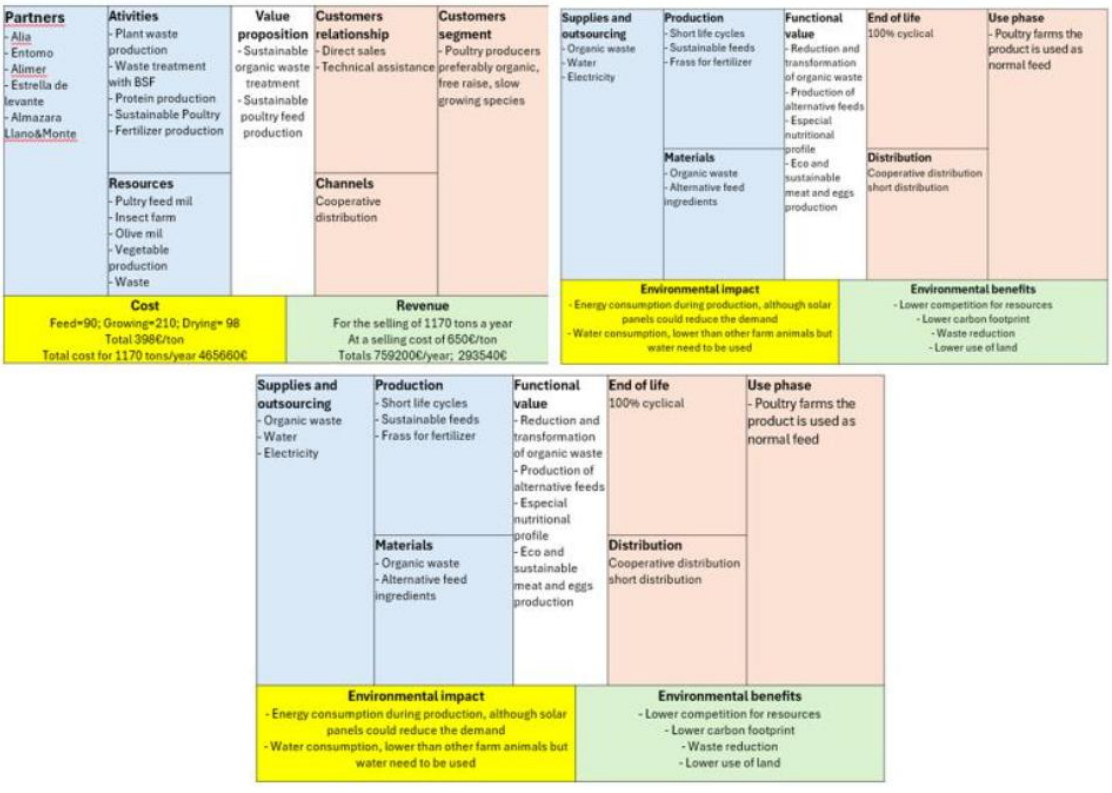
- Circular Canvas: Visual tool for designing sustainable business models.

- Triple Layered Canvas (TLBMC): Integrates economic, environmental and social layers.

- Circulytics (Ellen MacArthur Foundation): Measures your business circularity.

- Ecochain, SimaPro: Software for measuring environmental impact and carbon footprint.

Explore databases like ECESP or CEDb to find real-life circular examples and join networks like the Circular Economy Club for peer learning and support.



Triple Layered Business Model Canvas (TLBMC)

1.6 Inspiring Success Stories

Adnams (UK): Uses brewery waste to produce biogas for factory energy.

Naranjas del Carmen (Spain): Reuses pruning waste for compost, reduces food waste, and sells directly to consumers.

Nestlé + Carrefour (Spain): Reusable packaging system (Loop) to reduce plastic waste.

La Fageda (Catalonia): Generates energy and fertilizer from livestock manure.

Barilla (Italy): Turns wheat by-products into animal feed and uses recyclable packaging.

These examples show that circular economy is not only possible, but profitable and scalable in diverse contexts.

1.7 Final Checklist and Next Steps

How to know if you're ready to transform your business:

- Have you identified your main resources and waste?

- Can you recover or reuse some of that waste?

- Have you explored technologies or partnerships to support the transition?

- Have you defined your circular value proposition?

- Can you measure and communicate your positive impact?

If you answered 'yes' to several of these questions, you're on the right track. Start with a pilot, measure outcomes, and expand. The circular economy is not only an environmental commitment—it's an opportunity for innovation, efficiency and leadership.

2. Circular Economy business model Murcia Region

2.1 Introduction to CEBM in Murcia

Murcia, as part of the SUSTAvianFEED regions, has been identified as the location for the main development of the CEBM. As will be seen later in the document, Murcia is a region with a large agricultural, livestock and food processing activity. This allows for great potential in terms of the development of CEBM, as it allows for the closing of the economic and resource circle in a given location. Although circular economy models can be applied to a single company, we have sought to develop a model in which several entities participate, thus seeking a greater benefit for the entities involved and thus increase the impact of the model in the region.

This section aims to apply the systematic process of creating the CEBM presented in section "2. Implementation" but for ease of reading, sections have been grouped together to allow a better understanding of the process. Also to simplify the process, the process is shown once the conclusions have been finalised, although if you wish to find more details, you can look for more information in the annexes.

In the first instance, the companies of interest in the area are listed, the outputs and inputs resulting from their activity are listed, an evaluation is made of the logistics and intrinsic productivity of each substrate and finally a model is created to be evaluated. With the model already created, a robustness study is carried out to help see how durable the model can be over time and what the risks of applying the model are.

2.2 Location description

1. *Geographical Location*

- Coordinates: The Region of Murcia is located in the south-east of the Iberian Peninsula, between latitudes 37°23' and 38°45' N and longitudes 0°39' and 2°21' W.

- Proximity to Markets: Murcia is strategically located close to important national and international markets, especially due to its proximity to the Mediterranean coast. This facilitates the export of agricultural and livestock products to other parts of Spain and Europe.

- Transport: The region has a dense network of roads and motorways, such as the A-7 and the AP-7, which connect Murcia with other autonomous communities and with the rest of Europe. The International Airport of the Region of Murcia and the Port of Cartagena are essential for the transport and export of agricultural and livestock products.

2. *Physical Aspects of the Territory*

- Topography: Murcia has a diverse topography, with plains on the coastal strip and mountain ranges inland, such as the Sierra de Espuña and the Sierra de Carrascoy. The flat areas, such as the Guadalentín Valley, are suitable for intensive agriculture, while the mountainous areas are mainly used for extensive grazing.

- Climate: Murcia enjoys a semi-arid Mediterranean climate, characterised by hot, dry summers and mild winters. Rainfall is scarce, ranging between 300 and 350 mm per year, which influences the need for irrigation and livestock farming practices.

- Soil: Soils in Murcia vary, being mostly calcareous, with fertile areas in the meadows of the Segura River and its tributaries. These soils are ideal for intensive agriculture, although their management requires efficient water use.

- Water Resources: The Segura River is the main water source in the region, essential for crop irrigation. In addition, groundwater and technician irrigation systems, such as drip irrigation, are used to optimise water use in a region with low rainfall.

3. *Agronomic and Livestock Aspects*

- Types of crops: Murcia is a leader in the production of fruit, vegetables and citrus fruits. Among the most important crops are lettuce, tomatoes, peppers, melons, lemons and table grapes. In addition, fodder crops such as alfalfa, essential for livestock feed, are grown.

- Agricultural yields: Agriculture in Murcia is highly productive thanks to advanced technology and efficient irrigation. The region is known as "the market garden of Europe" due to its great capacity to export fresh produce.

- Livestock: Livestock farming in Murcia focuses on sheep, goats, pigs and, to a lesser extent, cattle. Extensive livestock farming is common in mountainous areas, where the terrain is not suitable for agriculture. Lamb and goat production is

traditional, and pig production is well developed, with a significant processing industry.

- Feeding and forage: The production of forages such as alfalfa is essential for livestock feeding. However, limited water availability in the region makes it necessary to optimize production and rely on feed supplements for livestock during the drier seasons.

4. *Agricultural and Livestock Infrastructure*

- Irrigation Systems: Murcia is a pioneer in the use of irrigation technologies, especially drip irrigation, which maximizes water efficiency in an arid region. This system is essential to maintain agricultural productivity in the region.

- Livestock infrastructure: The region has modern livestock handling facilities, including stables, corrals and automated feeding systems. In addition, there are slaughterhouses and meat processing plants, which add value to local livestock production.

- Agricultural and Livestock Technology: The use of advanced technology is common in Murcia, both in agriculture and livestock farming. Sensors, water management systems and modern agricultural machinery are used to optimise production and ensure sustainability.

5. *Socio-economic Aspects Related to Agriculture and Animal Husbandry*

- Rural Population: A significant part of the population of Murcia is involved in agricultural and livestock activities. The region has a rich agricultural tradition, with a deep knowledge passed down from generation to generation.

- Land Ownership and Tenure: The structure of land ownership in Murcia includes both large farms and small family farms, especially in rural areas.

- Markets and Trade: Murcia is one of the main agricultural exporting regions in Spain. The region's products are traded both domestically and internationally, with a particular focus on exports to Europe.

- Government Policies and Support: Farmers in Murcia benefit from various policies and subsidies, both at regional and national level, which support farm modernisation, water management and sustainability.

6. *Challenges in the Agriculture and Livestock Activity*

- Climate Risks: The Region of Murcia faces significant challenges due to water scarcity, drought and climate change. These factors affect both agricultural and livestock production, making it essential to adapt to new techniques and technologies.

- Soil problems: Soil erosion and salinisation are critical problems affecting agricultural productivity in some areas of Murcia. Sustainable soil management is vital for the continuity of production.

- Animal Health and Pests: Livestock farming in Murcia faces challenges related to animal health, such as disease prevention, as well as the management of pests that can affect both crops and pastures.

7. *Agricultural and Livestock Potential*

- Expansion Zones: The region has areas with potential for the development of new agricultural and livestock activities, especially in the improvement of pastures and the introduction of crops and livestock breeds more adapted to the arid climate.

- Innovation: Murcia is well positioned to lead in agricultural and livestock innovation, with opportunities to integrate new technologies and sustainable practices that improve efficiency and profitability.

- Diversification: There are opportunities to diversify production, including organic farming and the production of livestock products with designation of origin, which can add value and attract new markets.

8. *Development Projects and Plans*

- Ongoing initiatives: Murcia has several projects focused on improving agricultural and livestock infrastructure, such as the modernisation of irrigation systems, the development of new and more resistant crop varieties and the strengthening of the livestock value chain.

- Future Planning: The region has long-term plans to ensure the sustainability of its water resources, promote precision agriculture and expand the production of high-quality food for premium markets.

As can be seen in the description of the territory, the region of Murcia is a territory where a large part of the population lives in rural areas and with a very dynamic and productive agriculture, ranging from planting to the processing of vegetables for their commercialisation. Livestock farming is also an important economic

driving force. On the other hand, one of the major constraints is the scarcity of water and the evolution of the land towards desertification. Intuitively, any circular business idea that includes the collection of agricultural and livestock waste, its transformation into products that can later be used in animal feed and fertilisers, and consequent savings in water consumption, will make good economic and environmental sense.

2.3 Enumeration of nearby companies

To start with the process of creating a CEBM in Murcia, we first proceeded to list the companies of interest that exist in the region. Using company directories, we searched for: (a) primary producers of fruit and vegetables, as this is one of the major resources available and because it is necessary in the following links; (b) fruit and vegetable processing companies because they generate waste that can be incorporated into the system; (c) dairy and brewing companies that can also provide resources; d) companies producing animal feed that can absorb the production of larvae; e) companies producing pickles to absorb the waste from larvae production; f) oil mills producing oil, which is a very abundant product in the Mediterranean basin; g) other companies that improve the model.

Fruit and vegetable companies:

Fruit and vegetable companies generally produce a large amount of waste associated with products that do not comply with market quality such as size, weight or colour, but also because they are damaged by pests or broken during harvesting (in the case of fruit). In another type of product, vegetable production companies generate a lot of waste that is left in the field as a by-product of production. For the sake of convenience, companies that produce and process for marketing fresh produce have been introduced, which also generate many by-products in the process. Table 1 lists the agricultural companies that were initially selected.

Table 1. List of companies producing vegetables in Murcia

Fruits and vegetables producers	Location
Grupo Hortofrutícola Paloma	- La Palma
Frutas Esther S.A.	- Abarán
El Dulze Growers S.L.	- San Javier
SAT Perichán	- Mazarrón

Surinver	- Pilar de la Horadada
El Ciruelo	- Alhama de Murcia
Agrícola Santa Eulalia S.L.	- Totana
SAT Hortiberia	- San Javier
SAT Agrimur	- Lorca
Agromurgi S.L.	- San Javier

Fruit and vegetable processing companies:

This group includes companies in the canning industry that make various preparations, including producers of juices and juice purées, porridges, canned tomatoes and preserves in syrup. These companies generate many by-products in the form of peelings, pulps, damaged fruits and products that do not meet the required quality. A table showing the companies in this sector is shown in Table 2.

Table 2. Companies manufacturing preserved foods in Murcia

Preserved foods	Location
Hero España S.A.	- Alcantarilla
Jufer S.A.	- Molina de Segura
Cofrusa (Conservas de Frutas S.A.)	- Alguazas
Conservas Ybarra Murcia S.L.	- Murcia.
Conservas Caravaca S.A.	- Caravaca de la Cruz
La Pastora S.A.	- Murcia.
Conservas Vega Alta S.L.	- Cieza
Conservas Hida Alimentación S.A.	- Mula
Conservas Helios S.A.	- Murcia.
Conservas Caparrós S.A.	- Murcia.
Conservas Vega Mayor S.A.	- Lorca
Conservas Bonny S.L.	- Murcia.

Dairy and brewing companies

The list includes companies involved in the production of dairy products, as they can be used in insect rearing. In most cases, for example, cheese dairies can provide whey, dairies can provide milk that has been acidified, and dessert producers can provide poorly made desserts and other products. Table 3 shows the companies in the dairy sector.

Table 3. Companies Producing dairy products in Murcia

Dairy production	Location
Central Lechera Murciana (CELMUR)	- Murcia.
Lácteos del Segura S.L.	- Cieza
Postres Reina S.A.	- Caravaca de la Cruz
Quesería El Roano	- Bullas
Lácteos La Ermita	- Molina de Segura
Quesos La Yerbera S.L.	- Murcia.
Quesería Alimer	- Lorca.
Quesería El Roano	- Bullas
Estrella de levante	- Murcia.

Feed companies

Due to the nature of the project, Alia is considered as a relevant company in the manufacture of poultry feed and no other company in this sector is included in this section. Alia has a great experience in the manufacture of poultry feed and especially considering sustainable ingredients.

Companies producing pickles and olives

These companies are added to the list because they have a dual function, on the one hand because they produce by-products when making pickles such as vegetable pieces and trimmings, and on the other hand because they consume a by-product of chitosan production such as NaOH, which is used for the curing of olives. The companies in this sector are listed in Table 4.

Table 3. Companies producing olives a pickle in Murcia

Companies producing pickles and olives	Location
Grupo Ybarra Alimentación S.L.	- Alcantarilla
Encusa S.A. (Encurtidos del Sureste)	- Murcia.
Agridemur S.L.	- Murcia.
El Faro S.A. (Aceitunas y Encurtidos)	- Alcantarilla
Aceitunas y Encurtidos El Gallo S.L.	- Murcia.
Aceitunas y Encurtidos Ballester S.L.	- Murcia.
Aceitunas y Encurtidos La Española S.L.	- Murcia.
Aceitunas y Encurtidos Montes S.L.	- Murcia.
Aceitunas La Torre S.L.	- Torre-Pacheco
Aceitunas Periche S.L.	- Murcia.
Aceitunas Bética S.L.	- Murcia.

Olive oil mills producing olive oil

The olive tree is one of the products that are present throughout the Mediterranean basin. Normally, olives are processed in olive oil mills, where various waste products such as pomace and alpechín (Spanish word for vegetative water) are generated, which in fact cause a great environmental problem. Fortunately, alpechín and pomace can be ensiled and used throughout the year and serve as food for the larvae. This reduces the environmental problem of waste while generating a new product. Table 4 shows companies in this sector.

Table 4. Olive mills located in Murcia

Olive oil mills producing olive oil	Location
Almazara La Rambla	Puerto Lumbreras
Almazara San Nicolás	Cieza
Almazara Deortegas	Yecla.
Almazara Valdelaparra	Molina de Segura
Almazara García Armero	Algezares
Aceites Cazorla y Parra S.L.	Caravaca de la Cruz
Almazara del Río Mula	Mula
Almazara Virgen de la Salud	Mazarrón
Almazara El Tendre	Alcantarilla
Aceites Lorquimur S.L.	Lorca

Other companies

To make the model more rounded, a few companies have been selected that help to understand the CEBM and give the system greater sustainability. On the one hand, biodiesel production companies have been included, which can take advantage of the oils extracted from the larvae and on the other hand, companies that produce fertilisers locally that can absorb the production of larvae. With the addition of these companies, no substantial waste would be generated in the implementation of the CEBM

To start with the process of creating a CEBM in Murcia, we first proceeded to list the companies of interest

2.4 Inputs/outputs of enterprises

To continue with the creation of the model, we proceeded to list the type of input or output that the companies have. To facilitate the model, only the inputs and outputs that are of interest to the model have been considered, either because their outputs are needed in the form of waste or because they need some output. Also to facilitate the model, a quality factor has been added to the quantities of inputs obtained, which would be the quality contributed to the system, since, for example, a tonne of lettuce (practically water) does not have the same nutritional value as a concentrated fruit pulp. These quality values have been assigned based on previous experiences in Entomo. Also to make the model more comprehensible, it has been chosen to divide the waste production by weeks, although the waste is often unevenly distributed throughout the year.

2.5 Logistics evaluation

Distance is a major factor in the creation of the CEBM, transporting waste, especially if it is plant waste with a high proportion of water, can place a heavy burden not only on the cost of production but also on the sustainability of the system.

As indicated in section 2, logistics has a great influence on the creation of the model, in order to better select the companies that can become part of the model, a row has been added to the selection matrix that takes into account the distance that exists between Entomo (which will receive the waste) and the waste giver. In order to facilitate the development of the model, the main site has been taken into account and no other sub-sites that it may have. Table x7 shows the results.

2.6 Creating the connection

Once it was decided which companies could participate in the model, they were contacted to better understand their willingness to participate in the model, as well as the details of disposing of their waste or purchasing the products, in order to ensure the long-term development of the model.

Interviews (LL) were conducted to help gather the information and a summary is given in table x8. For more details, please refer to the Annexes.

2.7 Creation of the model

After the analysis carried out, a model has been created that complies with the principles of circularity. The model includes the business partners of the SUSTAvianFEED project in the region of Murcia such as Alia as a feed producer and

Entomo as a producer of black soldier fly. To start describing the model the by-product producers will be taken.

Waste production:

After having considered all the nearby options as waste suppliers, the following have been considered, due to their proximity, availability of products throughout the year and the suitability of these products:

- **Estrella de Levante**: a brewery located in Murcia (71 km), produces beer and in the process generates around 20 tonnes of beer bagasse per day. The residue is rich in protein and fibre. The substrate tends to decompose quickly so it either must be kept refrigerated or consumed frequently.

- **Almazara Llano & Monte:** a company dedicated to the production of wine and oil, produces around 20,000 tonnes per year of alperujo (Spanish name for dry olive pomace) or the equivalent of 50 tonnes/day. The company is in Mula (33 km). The alperujo is characterised by a relatively high fat and protein content, but low in carbohydrates.

- Alimer: Cooperative society located in Lorca (65km) with 1800 members including farmers and stockbreeders. It stands out for its agricultural production of fruit and vegetables, which produces an approximate waste of around 20 tonnes per day throughout the year but divided into different seasonal products. It also produces goat's cheese, which produces approximately 2 tonnes of whey per day. Both products are interesting to produce larvae. In the case of the fruit because of its sugar content, which facilitates the growth of the larvae, and in the case of the whey because of its sugar and whey protein content, which are of high quality.

In addition to the companies that are highlighted to form part of the model, waste will be taken from other companies, such as Hida, Postres Reina, Patatas Rubio and other companies, which may form part of the model more sporadically due to seasonality or the exceptional nature of the waste.

BSF Farm (Entomo):

All residues are collected as often as necessary to remove them from the source and to create a necessary feed formulation. In the case of alperujo, it will be collected during the oil production season and stored in ponds and covered so that it can be ensiled and used throughout the year. For the formulation of larval feed, 33% beer bagasse, 33% alperujo, 25% fruit and 9% goat whey will be mixed.

This gives a total of 60 tonnes of larval food per day. From these 60 tonnes of food, about 10 tonnes of fresh larvae will be obtained which, when processed, will result in 1600 kg of protein-rich meal, 1600 kg of oils and 50 kg of chitosan. The use of the products will go to the following industries

- Protein: it will go to animal feed production, due to its good animal protein content of approximately 60%. Its easily digestible proteins are particularly suitable for feeding chicks.

- Hydrolysed proteins from the production of chitosan (200kg/day) will go to agriculture as a biostimulant for plant growth.

- Fats: 1300 kg/day of the total will be sold for animal feed. Very interesting for its qualities in the fattening of small animals and for its antibiotic properties.

- Chitosan: produced for its antibiotic properties and to prevent intestinal disorders in small animals, production is low.

As a result of the production of these raw materials, two main residues are obtained:

- Frass: which is the equivalent of manure. It is the result of larval feeding, where they leave undigested lignin and cellulose, and this is mixed with the excreta and microorganisms inoculated by the insects, giving a mixture which, depending on the feed provided, can be a good source of nitrogen, phosphorus and potassium as well as organic carbon. The frass will be consumed by Alimer in its crops. To make the system circular.

- 50% soluble NaOH. This could be considered a highly hazardous waste because of its caustic power, but it is also used for the production of soaps and for curing olives.

Feed mill (Alia):

This company produces about 12,000 tons of feed per month for various types of livestock. It is located in Lorca (65km). This company will receive the protein from the larvae at a level of 60%. The meal will be integrated into their feed as one of the ingredients.

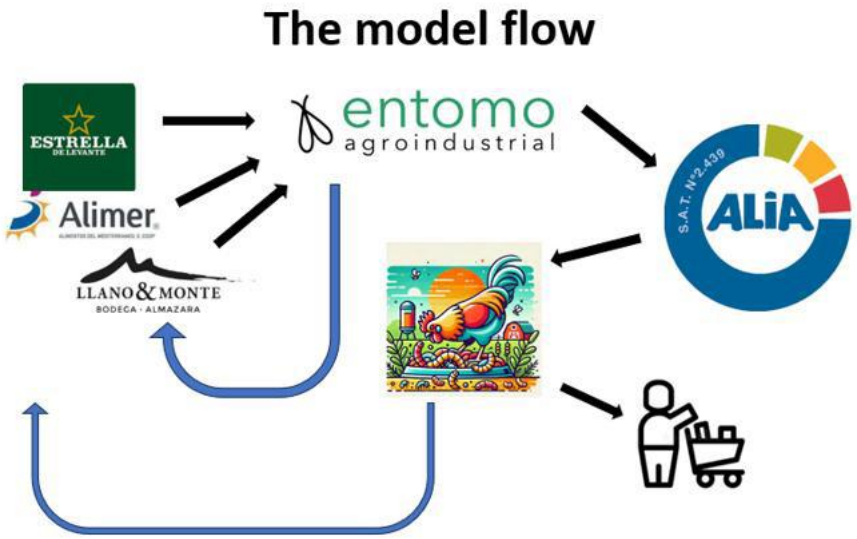


Figure 13. Material flow in the Murcia CEBM

Olive production company (Fruyper): This company is located in Murcia and is dedicated to the production of canned olives. The olive curing process requires the use of soda to carry it out.

These companies would complete the model, but some alternatives are proposed to make it more appropriate.

Biodiesel production company (TSK Biodiesel): Company located in Cartagena (106km) that produces biodiesel from used oils and other fats. The biodiesel produced can be used to move the lorries that transport goods from one place to another.

Fertiliser producing companies (Fervalle): company located in Lorquí (59km) that produces and markets a variety of fertilisers and can use frass as an ingredient in its formulations, especially for the organic line.

The TLCEBM for Murcia region was elaborated by the SUSTAvianFEED partners during the different CEBM workshops. And the result is shown below (see figure 14, 15 and 16)

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Partners	Atividades	Value proposition	Customers relationship	Customers segment
- Alia - Entomo - Alimer - Estrella de levante - Almazara Llano&Monte	- Plant waste production - Waste treatment with BSF - Protein production - Sustainable Poultry - Fertilizer production	- Sustainable organic waste treatment - Sustainable poultry feed production	- Direct sales - Technical assistance	- Poultry producers preferably organic, free raise, slow growing species
	Resources - Pultry feed mil - Insect farm - Olive mil - Vegetable production - Waste		**Channels** Cooperative distribution	
Cost Feed=90; Growing=210; Drying= 98 Total 398€/ton Total cost for 1170 tons/year 465660€			**Revenue** For the selling of 1170 tons a year At a selling cost of 650€/ton Totals 759200€/year; 293540€	

Figure 1: Economic layer of the TLCEBM in Murcia

Supplies and outsourcing	Production	Functional value	End of life	Use phase
- Organic waste - Water - Electricity	- Short life cycles - Sustainable feeds - Frass for fertilizer	- Reduction and transformation of organic waste - Production of alternative feeds - Especial nutritional profile - Eco and sustainable meat and eggs production	100% cyclical	- Poultry farms the product is used as normal feed
	Materials - Organic waste - Alternative feed ingredients		**Distribution** Cooperative distribution short distribution	
Environmental impact - Energy consumption during production, although solar panels could reduce the demand - Water consumption, lower than other farm animals but water need to be used			**Environmental benefits** - Lower competition for resources - Lower carbon footprint - Waste reduction - Lower use of land	

Figure 2. Environmental layer for the TLCEBM in Murcia

Supplies and outsourcing - Organic waste - Water - Electricity	**Production** - Short life cycles - Sustainable feeds - Frass for fertilizer	**Functional value** - Reduction and transformation of organic waste - Production of alternative feeds - Especial nutritional profile - Eco and sustainable meat and eggs production	**End of life** 100% cyclical	**Use phase** - Poultry farms the product is used as normal feed
	Materials - Organic waste - Alternative feed ingredients		**Distribution** Cooperative distribution short distribution	
Environmental impact - Energy consumption during production, although solar panels could reduce the demand - Water consumption, lower than other farm animals but water need to be used			**Environmental benefits** - Lower competition for resources - Lower carbon footprint - Waste reduction - Lower use of land	

Figure 3: Social layer of the TLCEBM in Murcia

2.8 Evaluation of the model

To evaluate the model and for simplicity, it has been evaluated just economically. To carry it out, interviews were carried out with different representatives of the companies involved in the model and other stakeholders with certain involved in the sector and which could affect the model. They were asked information such as the price at which they would sell the waste, the price at which they would buy the products, as well as if they would be willing to make contracts to stably supply the products, by-products, or waste. All the companies present in the model would supply waste to facilitate the model.

As a result of the interviews:

Estrella de Levante, which is a brewery located in Murcia, the main subproduct that could contribute to the model is the beer bagasse. This company could contribute about 40 tons a day of this product. The beer bagasse has economical value right now and thus it is sold at 26€ per ton.

In the case of Alimer, it would be enough to be able to contribute approximately another 20 tons of fruits and vegetables of different types. The ton of vegetables

would not have any cost, only the transport, which from the location where it is found to the factory is approximately 3 euros per ton.

In the case of the olive pomace, Llano del Monte, could provide approximately 40 tons a day as far as it is storage to be used after season. the price would be 6 euros per ton when collected fresh, and 0,5 € cost for storage and handling.

With all this in mind and considering the mixture created with different subproducts, Entomo would be able to make a production of larvae that with an approximate produce 21 tons of dry larvae per day. The production cost at this scale could be as low as 0.65€ per kg of dry larvae. However, if CAPEX is included in the economical balance and for an amortization period of 15 years, a product cost of about 0.95€ per kg could be considered. And to create interesting profits, a price of 1.3 € would be the most recommended.

Alimer could create feed with the insect larvae although it would be too expensive because it would be more expensive than what the soy costs in 2024 (350€ per ton). So, it doesn't seem reasonable to use BSF meals as a simple protein source. Anyway, under these conditions the company Entomo Consulting would not have benefits and therefore the model would fail if a profound change is not proposed. The model would make more sense for Entomo if it reached a sales price of about 1,300 euros per ton, but this selling price is simply out of range. With this, in the end, the model would be very difficult to be executed if it had to be evaluated from an economic point of view, but it would make sense if it is evaluated from an environmental point of view, since there is a certain amount of waste that is eliminated from the environment while there is a series of products that are produced. It should also be noted that when larvae are raised with the olive pomace, they accumulate polyphenols, giving them antioxidant and antimicrobial properties that could provide an extra value. as an ingredient, not as a source of protein, but due to the medicinal effect it can have e positive on chickens. In any case, still now this contribution on animal health is not yet economically evaluated and still BSF meal is considered more as a protein source than as an additive to improve chicken health. Thus, price is still a handicap. To offset price issues, considering than one of the most important factors for insects' production is energy cost due to acclimatation of the rearing chambers, the production cost could be sharply decreased if the location has more favourable climate conditions or if only seasonally production is carried out. If insects' production is done in favourable climate conditions, production cost could be cut to 0,45 and profits

could be seen at 0.75 €/kg. This price would be still expensive as protein source but more suitable to be incorporated in chicken feeds.

2.9 Robustness check

The study of robustness is a part of the process to be able to evaluate how stable our business model would be when faced with a series of cases that could affect it in the future. There are many ways to do a robustness study of the model, but for this guideline it is going to be used a simple study identifying possible risk (stress factors) and giving a score to check which one of the stress factors could be a risk in the system and decide how each of them will affect the system in general. It helps us to be able to predict future failures of the model and apply corrections in other to make it more robust.

Identification of the stress factors and analysis

Stress factors are those one who could affect the model at a certain point. To simplify the model to each factor a score from 0 to 3 will be applied to each factor being 0, a very negative effect in the model and 4 a very positive effect on the model. and the main one identified for the study are:

Increase the price of raw materials for feeds (grains): it is understood that the increase in the price of raw materials could have an effect that could be positive or negative but considering that by increasing the price of raw materials used to produce feeds, possibly will produce an increase in the value of agriculture by-products. If grains increase the value, more by-products will be included on the feeds and then the price of this raw material will also increase. This, for example, would be clear in with the use of beer bagasse for the feeding of ruminants, if the price of the grain or the hey increases in price, also the cattle producers would consume more beer bagasse and therefore this would increase in value. However, the beer bagasse could be substituted for other byproducts like the olive pomace and field vegetables, and it could be considered that the increase in the price of raw materials would affect less the production of larvae than would do the livestock. Therefore, it would be considered that the risk is relatively low. Giving a score of **3 (favourable risk)**

Electricity price increase: In the case of increasing the prices of electricity, the production of larvae would be highly affected because the price of production depends enormously on the energy needed to acclimatize the chambers. Therefore, in the case of an increase in the prices of energy, the price of production

of larvae would greatly increase and, consequently, its production would be commercially unfeasible. Giving the score to this stress factor of 0 (very considerable risk)

Increase price of fuels: In the case of an increase in the price of fuels, it could be considered that fuel prices will naturally increase. Therefore, the price of raw materials that are used in the production of larvae would increase. However, the price of by-products transport, considering that it is close, is less affected by the price of oil than those raw materials that come from far away. Therefore, it would be less affected than other raw materials that are imported. It gives a score of 2 (some risk)

Geopolitical changes: Geopolitical changes could be considered to affect the price of raw materials. In any case, those geopolitical changes, as they affect more the relations between the countries, it is very possible that those relations between the countries would affect the price of raw materials. This could mean that the importation of raw materials would be difficult, as the production of larvae would not depend so much on these imports, it would mean that it would be less affected or even be benefited by geopolitical changes, since the proximity of the production of larvae would make it a resource to take into account in substitution of other raw material resources. It gives a score of 4(very positive)

Water scarcity: In the case of water scarcity, the model would not be as affected as it is seen in other productions. For example, grain production is extremely dependent on rain, and water scarcity and drought directly affect it. In the case of the production of BSF, residues usually used already have a moisture and do not need to consume so much water. Therefore, it would be less affected or benefited by the scarcity of water. In any case, there are small details to consider. For example, in years of scarcity of water, less olive oil is produced and, therefore, there is less alperujo available. This means that part of the available alperujo is lost, or its price is raised. The beer bagasse production is not affected by draught, because although the value of barley increases due to poor harvest, the total cost of production is mainly paid by the one who consumes the beer and does not affect the sub-product so much, which would be the bagasse. It gives a score of 3 (favourable risk)

Periodical climatic stress (El Niño): Phenomena such as El Niño, of deep drought during a certain period, since we have already mentioned that the lack of water does not affect the production of BSF while it affects other sectors. In the case of

El Niño, normally the fisheries in Chile, Ecuador and Peru, decrease the production of fishmeals. This produces a great shortage of resources that increases the price of fishmeal and that therefore increases the price of BSF meal simply as substitute those sources of animal proteins that would no longer be available. It is a score of 4 (very positive)

As it can be seen, the biggest risk than challenge the model is the increase of electricity, so to create a more robust business model, it would be recommended to create a system with more independence of the conventional electricity grid and using more renewable energy sources like solar. In this way the increase of electricity process will affect the model in a lower extension. In addition to that, if BSF are produced seasonally, when the climate is more favourable, less electricity is needed, and the model will be more robust. In the case of Murcia region, weather is favourable for 9 months a year, so the production would recommend being done during this period and it will make the CEBM more robust. Thus, a system to store by-product during resting period would be a recommendation to give more robustness to the system

2. 10 Conclusions

As a conclusion, it has been possible to create a circular economy business model adapted to Murcia region in which, fortunately, there is a large quantity of agricultural resources that can be used.

For the business model created the by-products to produce the BSF procced from three different industries. The production of beer bagasse is done in Estrella de Levante, which allows to have a stable source to make the BSF larvae providing proteins. It is also interesting the production of Alperujo, which can be used to provide energy, organic acids and preservative for the diet, and this can be used for the complementation of beer bagasse from Estrella de Levante, it can be complemented with the production of goat cheese whey and the production of vegetables by Alimer, which would complement the larvae diet. All these by-products would be used for the production of larvae in industrial entomology. From there, two main products would come out. On the one hand, the frass, or fertilizer after the digestion of organic elements, which can be fertilized in agricultural companies. And on the other hand, dried larvae, which can be used by Alia to be one of the ingredients in the production of sustainable feed in the emulsion region.

After doing an analysis of the model, it can be seen that if the established model is based on high technology and a high level of climate control, there is a problem because the production of larvae is highly affected by energy cost and then the larvae will have higher cost than what the market could really pay for an ingredient for the production of feeds. Of course, if these larvae use were analyzed from an environmental or sustainability point of view, they could be very interesting, but that would not support the model from an economic point of view. However, the recommendation made, is to make the production of larvae seasonally skipping deep winter to decrease energy cost. In this case, the production cost would be low enough to be considered competitive, although it would not yet compete with the normal prices of other raw materials that are relatively low (soy and corn). In any case, considering that it is possible that the value of raw materials to produce feed increases in the coming years, it is also possible that the prices of BSF becomes more competitive. In addition, the fact that insect flours have a few properties that could be considered medicinal in chicken production could make them interesting, although not as primary ingredient, but as an additive to improve the quality of life of chickens or to improve their productivity.

The study of robustness of the model concludes that for many of the stress factor that affects the BSF production in a future scenario, most of them will favourably affect and will make more competitive it source than other raw materials. In other words, the risk factors that could happen in the future would affect other elements more than the production of BSF, due to the nature of being produced locally, not being severely affected by drought, nor by the increase in the price of oil, or even being improved by some other factors like geopolitical issues. However, there is a factor that produces a very high risk, which is the increase in the price of electricity, since the production of BSF is strongly affected by the prices of energy. This energy is used to climate the chambers. However, this risk could be greatly reduced if sustainable sources of energy were used, such as solar, which would decrease the dependence on the external electricity supply and, therefore, on the prices. This risk could also be reduced by simply produce during the time of the year when the climate is more favourable to carry it out, which in the case of the Murcia Region could be up to 9 months a year, leaving 3 months to clean the facilities and prepare them for use in the next season.

With all this, it could be said that this model of circular economy is robust if independence is sought with respect to electricity supply and the production cost of BSF is reduced.

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