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FoodE

WP2 - D.2.8

Literature review on innovative bioeconomy business models for City/Region Food Systems

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1. Executive Summary

The current report describes the developments and outputs of the FoodE (Food Systems in European Cities) European research project. Considering and integrating all the recent advancements on sustainability assessment of City Region Food System (CRFS), this work will develop a systematic literature on the different innovative business models applied in the food sector with a broad bioeconomy perspective for the CRFS. Starting from existing knowledge and on-going research already exanimated with the report on the Inventory of emergent BMs and review of innovative bioeconomy BMs, such document will pave the ground and support the future analytical decision support tool step for the development of innovative business models to enhance CRFS. In particular, since CRFS projects will cover new agricultural and industrial value chains and demand-driven innovations, resource recovery, efficiency, and sharing, circular supplies of renewable, recyclable or biodegradable materials, and product development aimed at reducing negative environmental, social and economic impact; it is important to identify the most relevant items related with the structure of different innovative business model.

These preliminary typologies will represent the basis criteria for the identification of a set of Key Performances Indicators (KPIs) related to the effectiveness and impacts of CRFS in their business models.

The Literature review on innovative bioeconomy business models for City/Region Food Systems presents the findings on business models in the food bioeconomy sector based on innovation and sustainability. It is conduct using the PRISMA methodology to collect the major scientific contributions on the broad topic of the food bioeconomy and innovative and sustainable BMs applied to the CRFS approach; trying to understand how these two topics are being addressed together by the scientific community to identify future developments for CRFS initiatives. Based on the research fields of the papers selected, the results of the report highlight the relevant topics of the food bioeconomy and their underlying business models, namely for urban and peri-urban agriculture, Alternative Food Networks, technological innovations (plant breeding, building-integrated rooftop greenhouses, vertical farming, aquaponics, smart farming & AI, block chain), product innovations (algae, insects), and food waste valorisation.

2. Background

2.1 FoodE project – Food Systems in European Cities

The continuous increase in the rate of urbanisation, the exploitation of natural resources and the consequent loss of them, as well as the effects of climate change are leading to European cities to increase their sustainability (Satterthwaite et al., 2010). It is therefore imperative to increase the sustainability of City/Region Food Systems (CRFS) to achieve food and nutrition security.

The systemic implementation of innovative food-related approaches is difficult due to the diversity of European cities and regions. The objective of FoodE is to accelerate the growth of citizen-led City/Region food systems (CRFS) by bringing local initiatives across Europe together, as well as co-developing and disseminating a range of tools - co-designed with academia, citizens, to ensure that current cross-sectorial knowledge is applied. Start-ups will also provide an in-depth understanding of the needs of the key stakeholders, ensuring that resilient food systems will be citizen driven.

The outputs of FoodE will impact job creation, promote local economy, and strengthen the role of local communities in complying with Sustainable Development Goals. Furthermore, it will identify and strengthen relations between the different actors of the food chain. The following steps are used in FoodE:

– Define an operational methodology for the assessment of CRFS.
– Promote cross-pollination between European CRFS.
– Contribute to increase access to affordable, safe and nutritious food.
– Create a tool mobilising CRFS stakeholder in sustainability assessment.
– Scale the output to other EU cities.

2.2 WP2 Objective

These specific activities carried out in the FoodE project will develop a methodological framework and an analytical decision support tool for the development of innovative business models to enhance CRFS, taking into account all recent advancements on sustainability assessment of CRFS. More specifically, FoodE WP2 will:

- Create an inventory of innovative CRFS projects.
- Develop an integrated methodology for the interpretation and analysis of innovative business models.
- Apply, validate and refine the integrated methodology on case studies, including a sustainability assessment. Revisions proposed by stakeholders will be integrated during cross-pollination (WP3).

- Develop business case reports and carry out comparative analyses to identify barriers and key drivers of change.
- Develop an analytical decision support tool, based on the FoodE integrated methodology, to support decision-making in innovative business models and to improve their performances and sustainability.

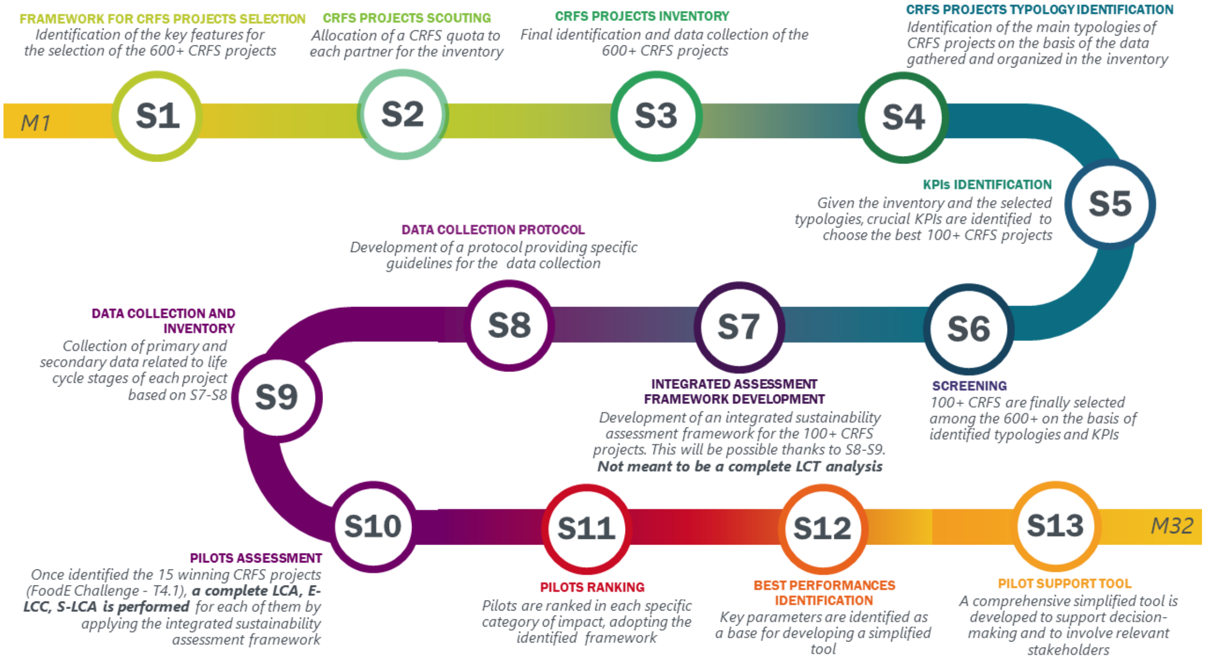

Figure 1: WP2 roadmap

2.3 Objective and output of T2.1

The specific aims of this activities are to provide a broad and clear review and inventory of innovative CRFS projects and models. A key challenge of the task is to aggregate the most sustainable models and enable co-creation of innovative pilot experiences. The final goal is to foster the health and well-being of European citizens. This challenge will be tackled using a co-created mechanism, based on Citizen Science and Responsible Research and Innovation principles. Here public authorities, citizens, business actors and non-profit organisations share ideas, tools, best practices and new models to support cities in becoming innovative food hubs.

This report identifies and characterizes new business to consider their potential transfer towards the identification and key factors of success of innovative and sustainable CRFS in the broader bioeconomy perspective. As such, it represents an added value outcome of the Review and inventory of innovative CRFS projects phase. The objectives of this report are to identify and describe new types of innovative and sustainable business models in the food bioeconomy sector based on innovation and sustainability.

In the first part of the report the different definitions and approaches of business model and bioeconomy are presented (chapter 3). Then, the explanation of the methodology and methods section are reported. The methodology of literature review was based on PRISMA method (chapter 4). The Last section presents the results of the analysis by the following classifications (chapter 5):

Classification	
	Innovation and food start-up information,
	Circular and Sustainable BMs in the broader bioeconomy perspective,
	Urban/peri-urban agriculture,
	Technological innovations,
	Product innovations,
	Food losses and waste prevention, reduction and valorisation.

3.Concepts: Bioeconomy and business models

3.1 Bioeconomy definitions

The bioeconomy can be defined as an economy where the basic blocks for materials, chemicals and energy are derived from renewable biological resources (McCormick and Kautto, 2013). The term "biomass" covers all organic materials that are not of fossil origin (Raschka and Carus 2012). The bioeconomy Council of the German Federal Government defines the bioeconomy as "the production and use of biological resources (including knowledge) to provide products, processes and services in all economic sectors within the framework of a sustainable economic system" (Bör, 2020). It comprises all economic sectors that refine biogenic resources with physical, chemical and biotechnological processes to produce primary, intermediate and end products. The bioeconomy thus encompasses a large number of sectors that have so far been considered separately or as flanking measures, but which are increasingly closely interlinked due to the common raw material "biomass" (SPITZENCLUSTER BIOECONOMY 2015). According to this, the bioeconomy is a sector centred around biomass or biological resources ((Pannicke et al. 2015 and Lödding et al. 2017).

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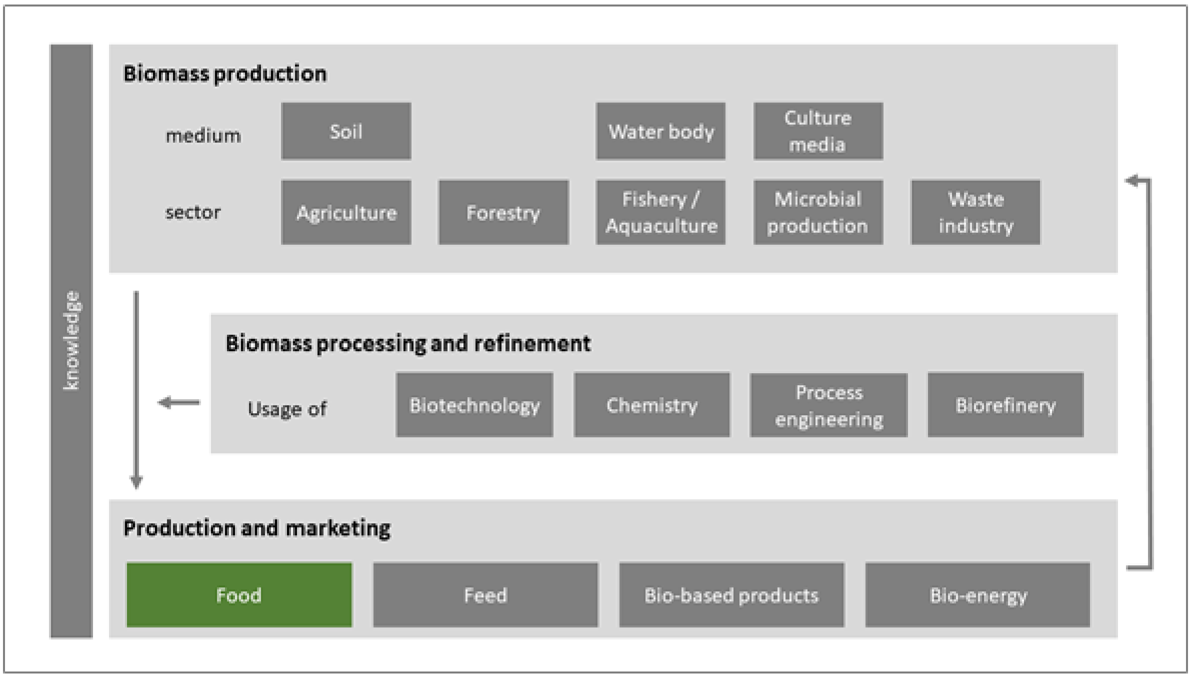

Figure 2 : The bioeconomy system and its value chains

The complex system bioeconomy is anchored in numerous economic sectors (Lainez et al., 2018). The variously mixed value chains of the bioeconomy system begin with primary production in agriculture and forestry as well as in fisheries and aquaculture (compare Figure 2). Basic biomass production provides the basis for the bioeconomy and at the same time forms the core element of the bioeconomy. In addition to conventional use as food and feed, biological resources are also used as raw materials for material and energy use. As a result, the cultivation of renewable resources has developed into an important pillar of European agriculture.

Downstream sectors treat and process renewable raw materials and biogenic resources into various products by means of (industrial) applications and processes. In addition to the chemical industry, these include food, wood, paper, construction, leather and textile industries, parts of the pharmaceutical industry and the energy industry. The related sectors of trade and services are also involved (Lödding et al. 2017).

The variety of products is much more complex and of higher quality in the material use of biomass (pharmaceuticals, wooden furniture, chemical base materials, etc.) than in the energetic use (electricity, heat and fuels). The value chain is relatively short in the case of energetic use and consists mainly of three stages (biomass production and supply, energy conversion and energy use). In contrast, the value-added chains for the material use of biomass consist of considerably more conversion stages and actors within the value chains.

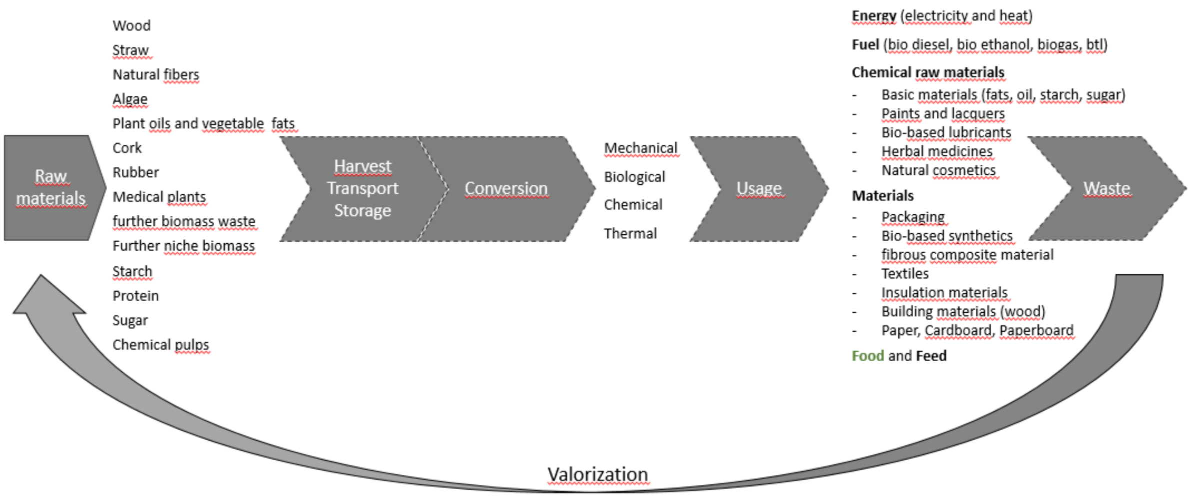

Figure 3 : Simplified bioeconomy process chain

The biotechnological conversion of biomass and the recovery of residual and waste materials are also central starting points. The waste management sector is also of essential importance, as it can ensure that residual and waste materials are used in the highest possible quality, thus enabling a closed-loop economy (BMBF and BMEL 2014). Therefore, environmental biorefinery could transform the residues of human waste, industrial and livestock effluents, coproducts of agriculture and agri-food industry in organic biomolecules. Organic human waste (food residues, urine, etc..) could be transformed into compost for the agriculture (Biswas et al., 2020) or biomolecules (organic fatty acids, etc.), for health, or alcohols for industry.

Bioeconomy poses new competitiveness challenges as well as opportunities for the European firms in all economic sectors. The development of bioeconomy could contribute to higher levels of economic and environmental sustainability. The societal demand for sustainable clothes, limited plastic packaging, and sustainable domestic products, et cetera provides the basis for innovative, sustainable, and circular thinking and behaviour in different industry sectors contribution to bioeconomy. As a consequence, the bioeconomy can contribute to address multiple societal challenges in the coming years: food security, climate change, sustainable resource management, private companies' competitiveness, job creation and the high dependence on non-renewable, fossil fuel-based resources.

Moreover, an increase in the production, transformation and recycling of renewable biological resources in industry can develop more circular and more sustainable economies. The substitution of fossil fuels can reduce greenhouse gas emissions, while preserving natural resources, biodiversity, and amplifying ecosystem services. Benefits from the development of circularity-oriented bioeconomy are potentially massive – compared to linear, fossil fuel-based economies.

The concept of business models can be a right tool and strategic management template to analyse businesses on a holistic level without losing sight of important adjustment screws and to characterize in the same time the key factors of success and the sustainability conditions. Hereafter we are going to focus on the food bioeconomy, highlighted in green in Figures 2 and 3.

3.2 Business Model definition

Concepts of business models aiming to set-up and analyse enterprises have risen in the mid-1990s, while its first appearance dates to the 1960s (Osterwalder, 2004; Henriksen et al., 2012). However, the wider appearance of the term business model is a relatively young phenomenon that has found its first peak during the web-hype at the beginning of the third millennium (Osterwalder, 2004) and frequently used since the arrival of digital and internet start-ups (Hedmann, Kalling, 2003; Porter, 2001).

- stand for the 'design of organizational structures to enact a commercial opportunity' (George and Bock, 2011: 83f.),
- describe 'the rationale of how an organization creates, delivers and captures value' (Osterwalder and Pigneur, 2009: 14),
- show 'how a firm is able to earn money from providing products and services' (Boons and Lüdeke-Freund, 2013: 9), and
- explain 'how value is created for the customers and how value is captured for the company and its stakeholders' (Henriksen et al., 2012: 31).

Business models offer an overarching explanation on how firms do business on a system level; they explain how companies conduct business (Henriksen et al., 2012). Organizational activities play an important role in the various conceptualizations of business models, which seek to explain how value is created and captured. The identification of the 'who', 'what', and 'how' are essential when analysing business models (Henriksen et al., 2012). Using these guiding questions, business models can help to clarify who are the target groups and customers, what are their needs, what is the company's value proposition for the targeted customers, and how is the company configuring its business operations. Therefore, BMs allow the analysis and the elaboration of the functions of the organization, focusing on their dynamic interdependences (Verstraete et al., 2012).

Osterwalder, Pigneur and more than 470 practitioners from 45 countries wrote "Business Model Generation" in which they present the strategic management template Business Model Canvas (Osterwalder, A. & Pigneur, Y., 2010). It is simple and understandable to describe a business with its underlying business model without oversimplifying entrepreneurial activities. It allows not only to document existing business models, but also to develop and visualise new business models. The four main components in the Business Model Canvas are customers, offer, infrastructure and financial viability covering the three arenas of feasibility, desirability, and viability.

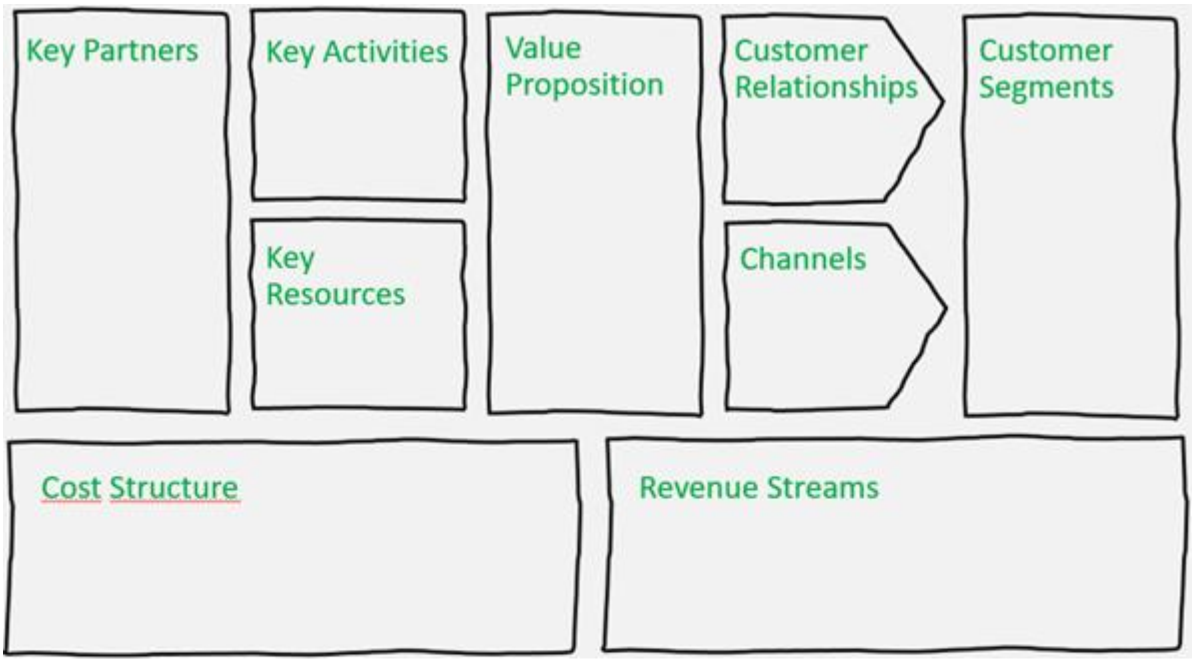

Figure 4: Business Model Canvas

These four main components are the backbone of nine basic building blocks, which are setting the Business Model Canvas like a blueprint (Osterwalder A. & Pigneur, Y., 2010). Business Model Canvas is a tool, which provides helpful overviews of companies to emphasize key success factors, to detect barriers, to compare competitors and to generate business ideas and innovations. "Although the canvas has a simple structure, it forms a complex system of interdependencies between the different elements" (Henriksen, K., Bjerre, M., Almasi, A. M. & Damgaard-Grann, E., 2012).

The nine building blocks are very briefly introduced below based on Osterwalder and Pigneur (2010).

Customer Segments

Customers are "the heart of any business model" (Osterwalder, A. & Pigneur, Y., 2010) and therefore this building block is the first one to pay attention. Enterprises aim to obtain and serve different groups of people or organisations. Therefore, companies cluster their customers into segments with mutual needs, behaviours and other characteristics.

Value Propositions

Value Propositions are "the bundle of products and services that create value for a specific Customer Segment" (Osterwalder, A. & Pigneur, Y., 2010: 22). It is an aggregated pack of products and services aiming to the requirements of specific Customer Segments. The Values can be quantitative as well as qualitative. Some often-provided Value Propositions are newness, performance, customization, design, brand, price, cost reduction, risk reduction, accessibility and convenience. The Channels and Customer Relationships interlock the Customer Segments with the Value Propositions.

Channels

The interfaces of a company with their customers are communication, distribution and sales Channels. Channels describe how an enterprise communicates with and reaches its Customer Segments to supply Value Propositions. An appropriate mixture of channels is crucial to satisfy customers.

Customer Relationships

Customer Relationships are the types of contacts linking an enterprise with specific Customer Segments. They "can range from personal to automated" (Osterwalder, A. & Pigneur, Y., 2010: 28). The main forces for customer relationships are acquisition and maintenance of customers and boosting sales.

Revenue Streams

The money a company receives for selling products and/or services to Customer Segments result in Revenue Streams).

Key ressources

Key Resources are the main assets, which are necessary to run a business model. "These resources allow an enterprise to create and offer a Value Proposition, reach markets, maintain relationships with Customer Segments, and earn revenues" (Osterwalder, A. & Pigneur, Y., 2010: 34). Key Resources, which can be divided in physical, financial, intellectual and human, are either of own possession or leased/purchased from partners.

Key Activities

Key Activities are required for Value Proposition creation and offering. Key Activities are the important actions an enterprise must do to run a specific business model. The main three Key Activities are production, problem solving and platform/network.

Key Partnerships

The network of suppliers and partners required for a working business model are the Key Partnerships. Enterprises team up with partners for business model optimization, for risk reduction or resource acquisition.

Cost Structure

Cost Structure summarizes the most important costs occurring in a business model. Money is required when creating and delivering value, maintaining contacts and generating revenue. Cost structures can range from fully cost-driven to fully value-driven. Cost-driven business models are focussing on cost minimization (low price Value Proposition, maximum automation, etc.), while value-driven business models are highlighting premium Value Propositions and personalized services.

In processes, where different stakeholders and long trading chains exist, "it is likely that an analysis of one individual business model does not sufficiently represent trading partners located up and downstream in the chain" (Lundy, M., 2012: 63). For consideration of influencing supplier and customer processes it is possible to link business models or to create system-wide business models, which are only meaningful in case of significant cohesion and collaboration between value chain actors (Lundy, M., 2012).

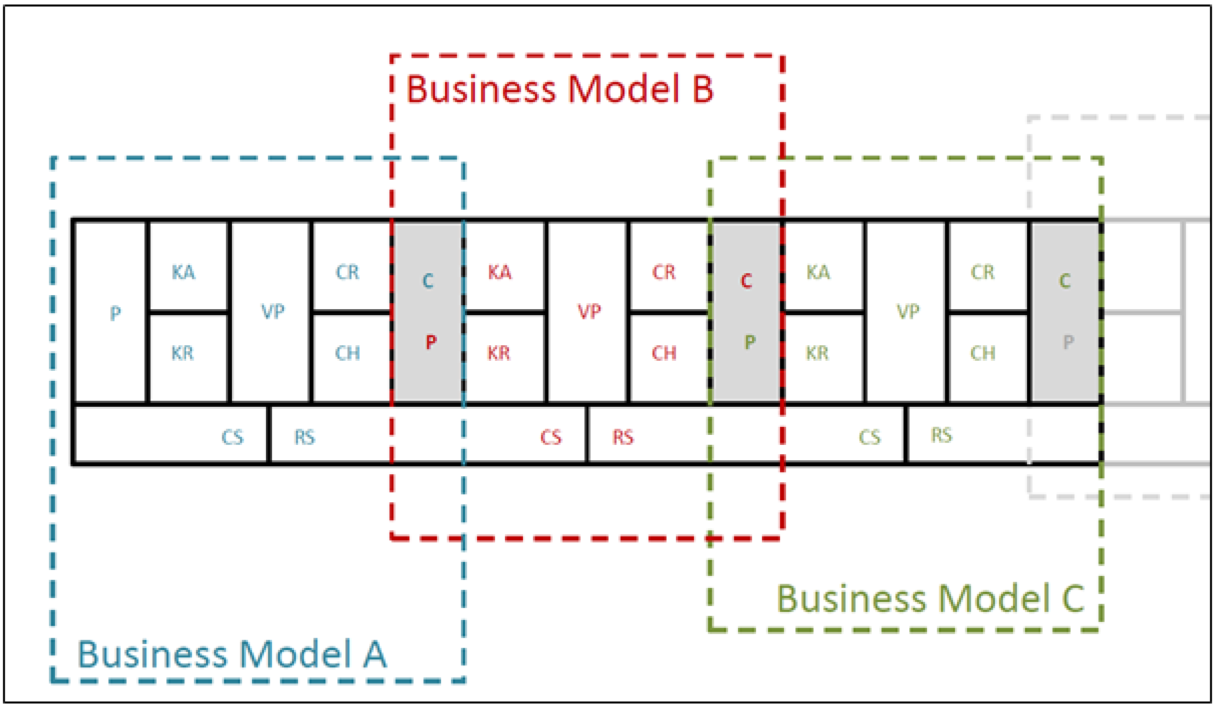

Figure 5 : Multi Stage Business Model (Source: LUNDY, M., 2012: 66)

The pure focus on the businesses' economics is increasingly under critique. Together with the growing relevance of circular-oriented bioeconomy and further progress towards sustainability and resilience, the one-layer BMC focusing on economics has been developed further. Lüdeke-Freund (2010), first, then Bocken et al. (2014), or Joyce and Paquin (2016), Yang et al. (2017), proposed different sustainability-oriented BM tools allowing companies to respond to economic, social and environmental challenges.

The triple layered business model Canvas by Joyce and Paquin (2016) seeks to account for the different dimensions of sustainability by adding two extra layers to the original BMC. The first extra layer represents the environmental life cycle of the product offered by the firm, and the second extra layer identifies the social impact on stakeholders. These three layers of observations could help the organizations to win competitiveness by exploiting the opportunities evidenced by a more holistic analysis of value creation that considers environmental and social sustainability goals. In the environmental layer the origin of the raw materials and their Eco conception is taken into account.

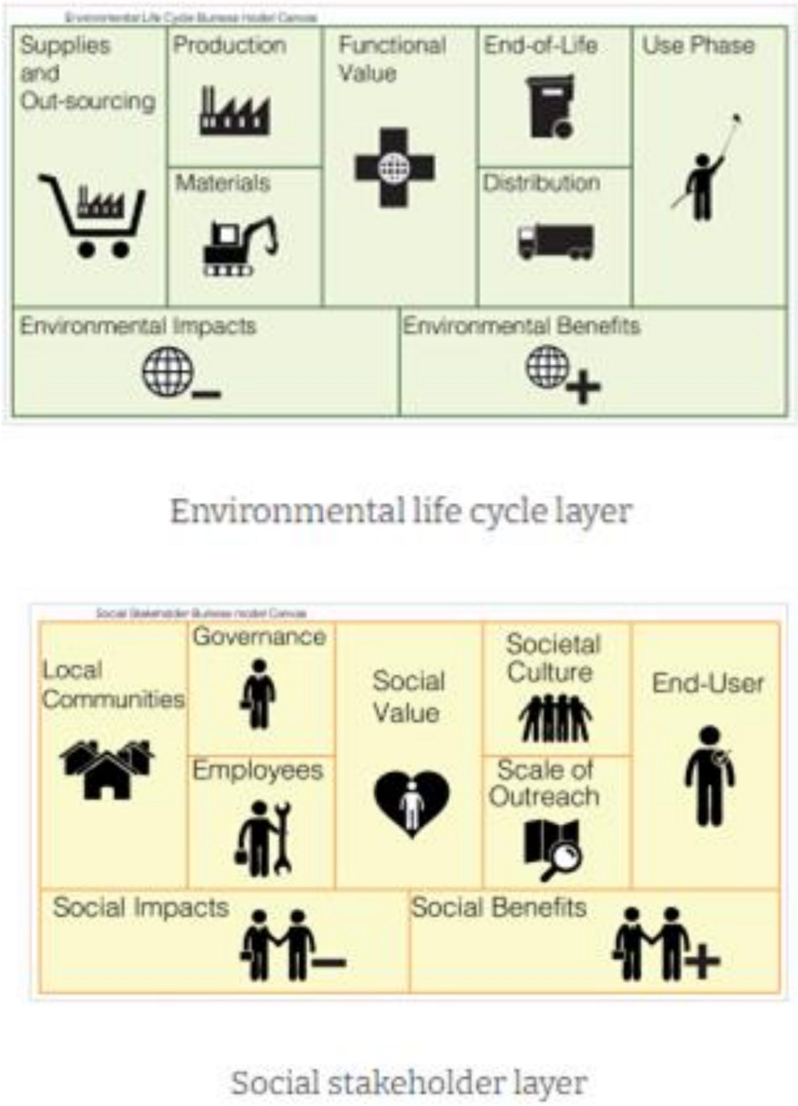

Figure 6 : Triple Layered Business Model Canvas, environmental and social layer (from Joyce & Paquin, 2016)

4. Materials and Methods

The objectives of this report are the identification of the state of the art on the bioeconomy sector and the characterization of business models with a focus on food, sustainability and innovation. The literature review is based on the PRISMA method (Preferred Reporting Items for Systematic reviews and Meta-Analyses). The PRISMA method aims to help authors in improving the reporting of systematic reviews and meta-analyses on a specific topic (Moher et al., 2009). The PRISMA method is adapted from a guidance developed by the QUOROM (Quality of Reporting of Meta-analyses). PRISMA addresses several conceptual and practical advances in the science of systematic reviews: a) *Completing a systematic review is an iterative process* i.e., the protocol of review needs modifications all along the review to be adapted to the scope and the result of the review. b) *Conduct and reporting are distinct concepts* c) *Study-level versus outcome-level assessment of risk of bias*. The review involves the assessment of the reliability and the validity of the data and the explanation of the method d) *Importance of the reporting biases.* In our case, the process of reviewing must include empirical, qualitative and quantitative studies.

This review consists of the identification of new concepts, tools and innovative business models in the bioeconomy. These criteria could help in characterizing the sustainability of the CRFS in terms of environmental, social and economic performances. Thus, these criteria enable us to assess the data from 100 innovative sustainable CRFS and pilots, to understand the viability of the CRFS and to identify models of replicability.

Firstly, the review of previous research allowed to discuss the concept of bioeconomy in all its aspects and industries. Bioeconomy is a concept including the use of renewable biological resources to produce food, products and energy. As such, it concerns many distinct industries. Secondly, the literature review focuses on bioeconomy and food. The list of relevant keywords must allow the most exhaustive review as possible in relation with our objectives combining bioeconomy, business model, innovation, food and characterization of assessment criteria (Table 1). The review is realized on the Scopus and Web of Science database and is limited to published papers from 2010 to present within the fields "article title", "abstract" and "keywords".

The search combined selected keywords and was limited to peer-reviewed papers. We combined keywords #1 and keywords#2 one by one with the Boolean operator "AND" and use "[…]" for terms consisting of 2 nouns e.g. "business model" (Table 1). 6,291 results were obtained at the first stage "Identification" of the search using 51 combinations (Fig. 7) . In the second stage, ~3,800 records were selected by reducing the number of combinations to best fit our scope.

In the third stage, we removed duplicates, conference proceedings, non-scientific contributions, resulting in 629 papers. In the fourth stage, these 629 references were scrutinized on the basis of title with eligibility criteria by 2 different persons. We deleted references which: a) were not written in English b) did not concern food (e.g. forestry, energy, fuel, pharmaceutics) c) presented specifications (production, technical, chemical, biological) without a link to business/socio-economics d) did not provide links to (items of) business model or business. As a result of this phase of "Screening" (fig.7), 275 references remained. In the fifth stage, the criteria were applied to the abstracts and represents the phase of eligibility (Fig. 7). Finally, 122 references were selected and used as the base of this report (Table 2).

Keywords #1	Keywords #2	Total of records keywords#1 + keywords #2
"Bioeconomy" and "Food" "Business model"	"Value" "Entrepreneur*" "Innovation" "Sustainab*" "Frugal" "Low-tech" "High-tech" "Environment" "Circular economy" "Consumers" "Market" "Nutrient*" "Urban area" "Peri-urban area" "Social impact" "Society impact"	6,291
"Bioeconomy" and "Food"	"Value" "Entrepreneur*" "Innovation" "Sustainab*" "Frugal" "Low-tech" "High-tech" "Environment" "Circular economy" "Consumers" "Market" "Nutrient*"	

	“Urban area” “Peri-urban area” “Social impact” “Society impact”	
“Food” and “Business model”	“Sustainab*” “Value” “Entrepreneur” “Innovation” “Frugal” “Circular economy” “Consumers” “Market”	
“Food” and “Business model” And “Sustainab*”	“Value” “Entrepreneur” “Innovation” “Frugal” “High-tech” “Low-tech” “Circular economy” “Consumers” “Market “Urban area” “Peri-urban area”	

Table 1: List of keywords for the literature review innovative bioeconomy business models for City/Region Food Systems

Keywords	Database	N° of records identified	N° of records based on criteria of interest	N° of records after duplicates, conferences processing, book, non-scientific contributions removed	N° of records Title and keywords screening with eligibility criteria	N° of records screening the abstracts with second set of eligibility criteria

51 combinations	Scopus & Web of Science	6291	+ 3,800	629	275	122

Table 2 : Number of records obtained at the different stages of literature reviewed

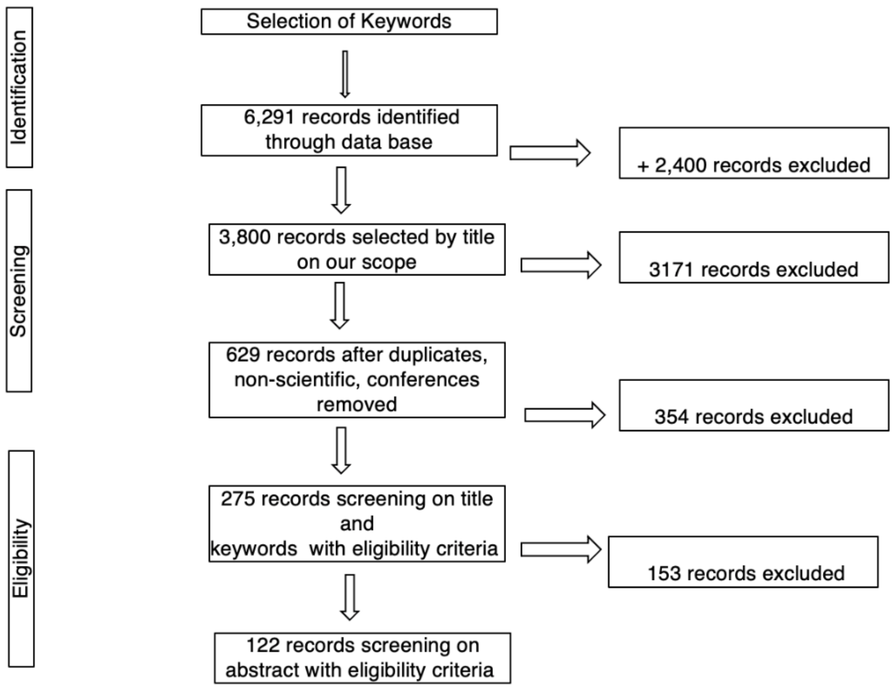

Figure 7 : Process of the selection of references

5. Sustainable BMs innovations in the food bioeconomy

5.1 State-of-the-art of innovative food bioeconomy business models

As confirmed by FAO, world population is rapidly growing and shifting from rural to urban areas: by 2050, this rapid increase in the urbanization trend will eventually result in cities hosting around 68 % of the global populace. Such development is greatly increasing the pressure on the agri-food sector: indeed, 80% of all food produced globally will be devoted to urban consumption. The negative socio-economic and climate-related impacts derived by the currently food chains are raising global concerns about the unsustainability of the system. Furthermore, the direct and indirect high costs of global food supplies produce a high volatility of food prices, which is severely impacting producers and consumers, in particular vulnerable groups. In addition to the anthropogenic pressure to which the food system is subjected, another concern is derived by the high demand of natural resources for the bioeconomy. While in the past bioeconomy directions were mostly focused on the exploration of renewable resources as a substitute feedstock for fossil fuels, recently new strategies are emerging to enhance the value of bio-resources also within the agri-food sector, by providing biomass for foods and other bio-based industries in terms of: raw materials from natural resources, renewable energy demand, as well as bio-chemicals and bio-pharmaceutical products (Diakosavvas & Frezal, 2019).

As stated in the Global Bioeconomy Summit 2020, the current rural and urban food systems occupy the biggest niche of the bioeconomy in Europe. For instance, it has been estimated that food systems, including agriculture, forestry, fisheries and aquaculture, as well as food and feed manufacturing, account for 71% of all value added in a bioeconomy, followed by around 28% for bio-products, and the remainder for bioenergy (IACGB, 2020).

The bioeconomy was initially focused on the substitution of fossil resources. Thus, biotechnological and chemical process were created to produce and to market food, fuel, fibres and molecules. Competition can occur between production of food or energy. So, the development of a sustainable bioeconomy and food supply chain calls for an approach of all the manufacturing plants under the frame of a circular model. Sustainable food systems face a wide range of challenges: increase productivity, employment and value addition; protect and enhance natural resources; improve livelihood and inclusive economic growth; enhance resilience.

The development of bioeconomy and innovative initiatives in food system need particular approaches, conditions and coordination of various stakeholders. Indeed, the stakeholder belong to very different organizations, private or public or caritative, with diverse capital of knowledge. The various stakeholders have divergent interests, different operating modes and operate according short or long term.

Loop of food production: Kopsahelis et al. (2019) present a holistic approach to food production for a sustainable bioeconomy era. Food losses from human food and agricultural production are estimated at one-third of human food production and represent an important waste. These wastes are composed of fruits, vegetables, cereals, meat, dairy or fish, potential sources of raw materials. From these food wastes, biotechnological process can extract high value molecules such as carbohydrates, lipids, proteins, or functional compounds that can be reintroduced in the food supply chain. For example, *Morchella sp.* is one of the most expensive mushrooms with a high nutritional value, and it could be produced on agro-industrial starch-based substrate coming from by-products of waste wheat grains or potatoes.

Mobilization and coordination of the actors and stakeholders: Monastyrnaya et al. (2017) promote a new template and guideline for the development of business models for a sustainable food value chain, by focusing on a sustainable pork value chain. The business model canvas allows for the description of existing and new businesses, but it seems to be ill-suited to sustainable business model modelling. Building sustainable food system requires the identification of the interests of stakeholders and actors in the three pillars of the sustainability: economy, society and nature. A large number of indicators and criteria explained by the diversity of sustainable issues should measure sustainability and/or value propositions. The actors need tools to identify their business strategy. The proposed business scheme requires the cooperation of stakeholders and actors and comprises 3 steps to build a sustainable food system:

1. Identification of needs of sustainability and value destroyed or missed with stakeholders;
2. Identification of sustainable practices and assignment of responsibilities along the value chain; and
3. Proposition of the sustainable value.

So, loop production, coordination and mobilization of actors are two important items for the analysis and development of innovative and sustainable CRFS.

5.2 Circular and Sustainable BMs in the broader bioeconomy perspective

Mili and Arfa identify a set of appropriate value creation processes for the success of organic food supply chains, with specific attention on the consumer standpoint (Mili & Arfa, 2020). To reach their aim, they proposed the Canvas business model approach of Osterwalder & Pigneur as a process to identify and design possible alternative solutions to value creation in a business, drawing possible what-if strategic scenario to directly reach the consumer's demand (Mili & Arfa, 2020). Through a business model survey, the authors gathered the opinion of different stakeholders on organic food supply chain issues: they identify the main expectations, needs and perceptions on the product, confirming the relevance of value creation processes in sustainable business models to promote the potential of urban food production (Plat et al., 2018).

Similarly, Borrello et all, offered a different perspective on the business-to-consumers relationships, suggesting the possibility to practitioners interested in circular business models to adopt innovative ‘food-product-as-a-service’ approaches (Borrello, Pascucci, Caracciolo, Lombardi, & Cembalo, 2020). The research emphasized the importance of customers participation into business modelling. The most relevant results highlight that consumers' food provisioning strategies and propensity to recycle are partially drivers of consumers' willingness to participate in circular business models. Other relevant drivers are some lifestyle measures, as for instance coping with risks of food provisioning, managing dependencies in food provisioning, convenience and social pressure towards recycling. (Borrello, Pascucci, Caracciolo, Lombardi, & Cembalo, 2020).

On the same topic of customers demand and value creation, Topleva and Prokopov stressed the relevance of using integrated BMs for the sustainability of food products. They propose an eco-design tool to create innovative eco-products with particular focus on the management of by-products (Topleva & Prokopov, 2020). The eco-design methodology is often applied to technological processes and technical characteristics of the products and environment, by rethinking their functionality. Its application for organic products allows to reduce the consumption of energy and water resources, to replace animal raw materials with plant raw materials, to have a low carbon and nitrogen footprint, and to establish a waste management system at each phase of the life cycle (Topleva & Prokopov, 2020). Thus, the eco-design is becoming a key tool for the bio-based economy and products.

Ulvenblad et al. analysed SBM from a firm perspective by proposing a new integrated method to map and analyse the sustainability innovation practices and the sustainable business models adopted by several agri-food companies. To reach their scope, they integrated a conceptual framework on sustainability-oriented innovation (SOI) and eight sustainable business model archetypes (Ulvenblad et al., 2019). The results highlight a broad variation of company profiles based on the different archetypes they match. An interesting result is that only 10% of organizations measure success solely in financial terms, while 80% measure success in all financial, social and environmental terms. Moreover, the most relevant archetypes identified are related to the maximization of material and energy efficiency and adoption of a stewardship role (Ulvenblad et al., 2019). These results are consistent with an ongoing transition towards more sustainable business models embodying a bioeconomy perspective, even though the study was carried out only in Sweden and hence it does not represent a general global pattern.

As hinted above, other authors approached SBMs from a systemic point of view, by proposing the concept of circular business model (CBM), framed also as business ecosystem (Moggi & Dameri, 2021; Zucchella & Previtali, 2019). CBMs are particularly interesting for the bioeconomy because they are designed to manage agricultural waste and by-products differently, by moving from a linear, 'take-make-dispose' economy to a sustainable usage of all constituents of renewable resources in cascading and circular pathways (Donner et al., 2021). More than leading to an optimization of resource management, CBMs also foster social innovation (Fortunati et al., 2020). CBMs are co-designed by a wide range of stakeholders (Moggi & Dameri, 2021) which are interconnected in a symbiotic relationship. Indeed, actors participating in a CBM collaborate to close loops by sharing resources and innovation processes.

Zucchella & Previtali shed a light on the features of a successful CBM by recognizing the pivotal role of a "focal firm" (Zucchella & Previtali, 2019) who acts as an enabler for the symbiosis with the other stakeholders involved in the circular ecosystem. An important contribution of this study is the recognition of the critical factors that should be addressed in the design phase of a CBM: a business ecosystem should be scalable and replicable in order to increase profitability, allow the access to public and private financing and in general to promote the circular economy (Zucchella & Previtali, 2019).

In their work on an urban network for the collection and redistribution of surplus food, Moggi & Dameri highlight that the success of a CBM stems from the presence of shared values and a sense of belonging among the participating stakeholders, that should also commit to knowledge sharing in order to avoid information asymmetry and promote cross-accountability (Moggi & Dameri, 2021).

5.3 Innovation and food start-up information

Incumbent food systems are largely decoupled from seasonality, are highly standardised and have constant availability and abundance of product brands (Horlings and Marsden 2011; Kuokkanen, Uusitalo and Koistinen, 2019). Innovations, which are important for business success, happen incrementally as well as disruptively – also in the food system (Kuokkanen, Uusitalo and Koistinen, 2019; Lestari, Rodhiyah and Najah, 2020). When it comes to disruptive innovations towards transition, it is not about the improvement of incumbent regimes' resilience. It is argued that disruptive innovations are necessary in the food system, because incremental innovation result only in smaller, often insufficient improvements of sustainability and resilience (Geels, 2004). Debates on disruptive innovations opened up from a primarily technological and product focus to entrepreneurial and citizen involvement allowing access to complete new markets and emergence of new business models (Kuokkanen, Uusitalo and Koistinen, 2019). This results in three fields of disruptive innovations: technological, product, and business models. However, papers primarily focus on product and/or technological innovations, while business model innovations are largely ignored (Ulvenblad et al., 2014).

Changing expectations and demands of users provide the basis for new business models and value offerings in the food sector. Business innovations need market as well as entrepreneurial orientation: listening to consumers, developing and exploiting new ideas, providing supportive environments for creative (business model) processes are keys for successful innovations. Sustainability-driven entrepreneurs can create more radical innovations, for their motivation may lie exactly in challenging the legitimacy of incumbent businesses and institutions by doing things they do not do (York and Venkataraman 2010; Dyllick and Muff 2016). Business model innovations in the food bioeconomy play an important role for food start-ups at any stage of circular value chains, in some way, building the DNA of a firm (Franceschelli, Santoro and Candelo, 2018). At the same time business model innovations can be more challenging than innovations of products or process. Yet, Lindgardt et al. (2009) emphasize that it is likely to result in higher performance and competitive advantages when carrying out business model innovation.

Kuokkanen et al. (2019) present distinct disruptive sustainable innovation in the Finnish food system; namely a) alternative protein-source products (burger patties from roach fish ("waste fish"); b) alternative distribution chains (online ordering, offline delivery); c) sustainable production; and d) community-oriented food (CSA, cooperatives, …). With regard to b), it is argued that online grocery shopping can potentially result in disruptive effects by reducing transportation and storage needs as well as cancelling the key role of retailers between producers and consumers. The sustainable production (see c)) means ideological and uncompromising food businesses, for what the customers are not only paying a price for a product or services, but also – or even mainly – for the created values and benefits. These sustainable production firms do "*deliberately acting in a different logic than the mainstream businesses*" (Kuokkanen et al., 2019: 759). Although these innovations do partly only have marginal market potentials, they expand the market in terms of scope and lead to systematic transitions, which can occur gradually (Geels, 2008). Ashlee-Ann et al. (2018) name examples which may facilitate transitions towards sustainable agriculture futures, like permaculture, aquaponics, vertical farming, urban agriculture, precision agriculture, smart and digital farming. They have the potential to create sustainability-oriented bioeconomies, circular economies, or local place-based food systems (Borrello et al., 2016; Hermans, 2018; Rossi, 2017). Similar to the alternative distribution chains presented by Kuokkanen et al. (2019) as one of four disruptive innovations in Finnish food system, Chen et al. (2020) emphasize in their study on e-commerce, sharing economy, and O2O (online to offline) as emerging innovative business models in food bioeconomy.

Nostratabadi et al. (2020) investigate in their paper business model innovations' contribution to the advancement of novel supply chains of food. They highlight three driving forces of business model developments or even innovations on the production/farmer side: rural female entrepreneurs, social movements, and urban conditions. These dominant driving forces are complemented with new technologies and environmental factors on the processor side; and e-commerce and Internet-of-Things on the retailer side. Regardless of the position in the value chain, actors have to consider consumption demand and product quality. Innovations for food sector's sustainable development comprise both, retro and forward-looking innovation (Leon-Bravo et al., 2019). Forward-looking innovation is a redesign of business models oriented towards sustainability (new products, reconfiguration of supply chain, new market segments), which is predominantly considered by comparable small businesses. The retro innovation sets a focus on traditional processes.

Business model innovations are also discussed in academia, emphasizing cereal-based food (Raymundo, Dolores Torres and Sousa, 2020), plant-based and cell-based meat (Broad, 2020), forests for food (Solberg et al., 2016; Chamberlain, Daar and Meinhold, 2020), genomics innovations (Jimenez-Sanchez, 2015), and sustainable commercialization of new crops (Jordan et al., 2016).

"Multifunctionality and circularity of resources are key considerations in the transition to sustainable agriculture systems" (Ashlee-Ann et al., 2018: 164). "The sustainable business model concept is used in reference to environmental and social aspects such as corporate social responsibility, business sustainability, sustainable agriculture, food security and safety and eco-system services" (Franceschelli, Santoro and Candelo, 2018: 2486). Sustainable innovations in the food sector are named to be winning strategies to gain business success. Overall, food system business model innovations have the potential to boost competitiveness and sustainability simultaneously, mainly by means of new value proposition and business management methods (Franceschelli, Santoro and Candelo, 2018).

5.4 Urban/Peri-urban agriculture

Therefore, the agri-food system is facing complex challenges. It should meet the growing global demand for food and agricultural products, while also meeting the increase demand for biomass supply for the energy and industrial sectors, all trying to be as sustainable and as resilient as possible.

The next chapter will focus on the analysis of the main innovation trends in the urban and peri-urban food bioeconomy. Some selected business cases will be scouted for internal and external success factors, hence by focusing respectively on their design features and on the conditions under which they perform best. Then, the review will discuss the potential benefits of circular thinking for the bioeconomy, highlighting the importance of promoting and championing the creation of business ecosystems. After having discussed the scaffolding of a successful sustainable business in the urban and peri-urban food bioeconomy, the study will zoom in on the main innovations as for the production processes and the products: a focus on technology and new foodstuffs will allow to explore the options for practitioners to optimize resources and to lower impacts. At last, a section devoted to food waste and losses will complete this overview by presenting the main strategies in addressing the waste of resources.

The urban and peri-urban agriculture (UA) has been recognized as a possible solution in the transition towards a more sustainable food system, since it provides a more resilient and sustainable approach to food supply in the wider frame of bioeconomy (Fortunati, Morea, & Mosconi, 2020; Mili & Arfa, 2020; Plat, Meyer, Schneider, & Perret, 2018).

Even though there is not a clear and established definition of urban agriculture (UA), the discussion on the role of UA towards a more resilient and circular food systems in cities are gaining momentum both in the political arena and in academia. UA has been principally divided between urban farming and urban gardening, but despite the following division, there is an increasing number of intermediate activities, such as some AFN (Alternative Food Network) or product and technological innovations, confirming that farmers and urban dwellers are acting jointly towards a resilient transformation (Plat et al., 2018). The report has investigated only the farming dimension, which aims at commercial goals, in order to identify innovative business models in the field with an overall bio economy perspective.

Business models (BM) have widely been used to emphasize production efficiency and economic performances for companies and organizations (Donner, Verniquet, Broeze, Kayser, & De Vries, 2021; Ulvenblad, & Tell, 2019). In the last decade, the surge of circular economy, sustainability,

and bioeconomy have led companies and organizations to innovate their business models (Donner et al., 2021). As highlighted by Donner et al., even though the relationships between these themes have not yet been fully explored, sustainability has become a key driver for business model innovation. The new sustainable business models step into evolution from the original concept of "exchange value" distributed to shareholders, to a modern vision of "shared value" for multiple stakeholders, including the society and the environment. In this context, sustainable business models (SBMs) are emerging as important strategic management tools for achieving a balance between making profits and addressing social and environmental concerns.
At an early stage, the innovation features of SBMs have been introduced in UA to enhance productivity, by proposing innovations focused on a more efficient resource management, as it is the case with climate-smart agriculture (Ulvenblad et al., 2019). However, the recent trends unveiled the multifaceted opportunities in urban agriculture for sustainable business model innovation (SBMI) for improving the circular bioeconomy in the urban and peri-urban context.

A literature review allowed to highlight the most relevant insights in this sense. In the frame of bioeconomy and urban farming, different authors have focused their research on the importance of sustainable business models as tools for simultaneously reaching the consumers requirements and delivering sustainable outcomes for the society and the environment. If compared to the traditional literature on BM (Zott, Amin, and Massa, 2011; Osterwalder & Pigneur, 2012), the academic work on SBM for urban and peri-urban agriculture presents some novelties that seek to address the new challenges opened by the bioeconomy: indeed, the implementation of sustainability in the BM calls for a systemic perspective, a focus on waste and by-products and a wider inclusion of stakeholders in the definition and implementation of business strategies. While some authors focused on the influence of customers and stakeholders on SBMs, other stressed the need to drop single-issue approaches and to adopt the systemic perspective of business ecosystem in order to explore ways of optimizing the resources and managing waste.

Donner et al. widen the perspective on critical success and risk factors by studying eco-innovative business model for urban initiatives. The results showed five main relevant macro categories and nine critical success and risk factors that can influenced the business of an initiatives over time:

(1) technical and logistic, (2) economic, financial and marketing, (3) organisational and spatial, (4) institutional and legal, (5) environmental, social and cultural	• innovative conversion technologies, • flexible in and out logistics, • joint investments in R&D, • price competitiveness for bio-based products, • partnerships with research organisations, • space availability, • subsidies, • agricultural waste management regulations, • local stakeholder involvement, • and acceptance of bio-based production processes

Table 3 : Critical success and risk factors (from Donner et al., 2021)

At last, Fortunati et al. offer a normative perspective on the benefits that CBMs could have for the agri-food sector by exploring the relationship between the principles expressed by the circular economy and corporate social responsibility. The authors discuss a set of benefits on the short and medium-long term, both for the company and for the society at large. For example, the company could enjoy greater productivity and safer working conditions for employees, while consumers would have access to higher quality products and the whole system will be more resilient to crises (Fortunati et al., 2020).

5.4.1 Alternative food network

A different perspective on the systemic conceptualization of the sustainable business models has been proposed by De Bernardi and Tirabeni, who applied a SBM framework to alternative food networks (AFN): they sought to identify the main drivers of success and to illustrate how they can contribute to foster anti-consumption behaviours, i.e. the attitude to consume less, differently or to use the consumption choices as a political stance. An AFN refers to the emerging local food networks in which producers and consumers have a direct relation; as such, they are alternatives to the more standardised industrial mode of food supply. As stated by De

Bernardi and Tirabeni, Alternative Food Networks (AFNs) can represent a sustainable and promising business models (SBM) for addressing the anti-consumption challenge by allowing the participation of consumers and producers in a community from which they can mutually benefit. (De Bernardi & Tirabeni, 2018).

In conclusion, circular and innovative BMs are widely recognized as pivotal in enhancing the sustainability impacts of urban agriculture activities and organic food towards the bioeconomy. However, as already stated by Donner, the relationship among sustainability, circular economy and bioeconomy needs further academic attention (Donner et al., 2021): a better understanding will positively affect the definition of innovative business models. In this sense, an overview on the main trends in technological innovation in the bioeconomy could help to understand the opportunities for upgrading processes and foster symbiosis. Other innovation opportunities could emerge from the exploration of new products such as microalgae and insects: these products require less inputs than conventional agriculture or animal production and can be employed in repurposing waste. Hence, the next two sections seek to address these topics by reviewing the main technological and product innovation in the bioeconomy.

5.5 Technological innovations

Technological innovation has the potential to be disruptive and transformative in many ways. It may have biophysical, economic and social impacts on food and nutrition security, as well as on the ways in which agricultural production systems are designed and operated (Klerkx et al., 2019). A prime driver for the bioeconomy is the need to ensure the availability of sufficient biomass production for food, feed, energy and industrial uses. This demand must be properly managed in the face of several challenges, including environmental changes and abrupt climate shifts (Malyska et al., 2017).

The aim is therefore to redesign agriculture to conserve land and water, as well as plant and animal genetic resources. To this end, the principles of bioeconomy are complementary to the biological loop of circular economy, which covers balancing renewable resource flows, optimizing resource yields and fostering system effectiveness (Malyska et al., 2017). Future agriculture should be environmentally non-degrading, technically appropriate, economically viable and socially acceptable (Pigford, et al.,2018). The innovative technologies will have pervasive effects on agriculture and food systems and major transformative potential (Klerkx et al., 2019).

Several of these technologies are currently operational or are being developed. Operational concepts include vertical farming, rooftop farming, digital agriculture, circular agriculture and aquaponics (Klerkx et al., 2019, Appolloni et al., 2020). Developing technologies are gene editing, synthetic food production, cultured meat or cellular agriculture nanotechnology, microalgae bioreactors, drones, internet of things, robotics and sensors connected to precision farming technology, 3D food printing, artificial intelligence and machine learning, and blockchain (Klerkx et al., 2019). These alternative agricultural technologies have the potential for creating bioeconomies and circular economies, or local place-based food systems (Pigford, et al.,2018). They will change the way agricultural supply chains function, and may affect the way food is produced, processed, traded and consumed (Klerkx et al., 2019).

5.5.1 Plant breeding

The availability of sufficient sustainably produced biomass feedstock is a prerequisite for the success of a bioeconomy. Plant breeding and breeding innovation are the cornerstone for a sustainable supply of biomass.

Breeding can improve the sustainability of the bioeconomy by (1) improving resource use efficiency of production; (2) improving yield and securing reliable harvests for increased resilience; (3) improving plant health by tackling prevalent diseases and improving resistance; and (4) developing plants with improved composition for (animal) nutrition (Malyska et al., 2017). Since the turn of the millennium, genetic crop improvements have already contributed approximately 74% to overall productivity growth, which is equal to a 16% increase in yields across all major arable crops cultivated in the EU (Malyska et al., 2017). In the future, plant breeding may also allow us to produce crops on land that are currently considered unsuitable, such as lands that feature a degradation of their biosphere by agrochemicals (~25% and ~45% of global land sources have severely or moderately degraded, respectively) (Abhilash et al., 2016).

5.5.2 Building-integrated rooftop greenhouses

Yield and efficiency can be further improved by controlling the production climate. Production in open-air conditions could achieve reasonable performance in certain periods of the year adopting the right technology, but the best results can be obtained in protected environments, such as greenhouses. For urban settings, rooftop greenhouses can be applied on top of buildings. It is worth noticing that this solution is particularly adequate for high and mid latitude regions.

The environmental performance of these greenhouses is improved by minimising water demand and integrating metabolic flows with the surrounding city. Soilless systems with closed-loop irrigation allow the farmers to save on water use and fertigation input. Water savings can also be achieved by the use of rainwater alongside tap water (Appolloni et al., 2020). Rooftop greenhouses can also integrate key flows with building metabolism to achieve an improvement of resources efficiency. The reuse of residual resource flows (energy, water and CO_2) between the building and the greenhouse can help reduce production inputs and consequently decrease the system's environmental impact (Appolloni et al., 2020).

5.5.3 Vertical farming in plant factories

Control over the production climate can be further increased in closed production systems, also known as plant factories or vertical farms. Vertical farms are a farming system based on the control of all environmental factors that can affect plant growth, including temperature, relative humidity, light and CO_2 (Appolloni et al., 2020). Vertical farms are disconnected from outdoor conditions and the production conditions are steered using sensors, climate systems, LED lights and hydroponic systems. This level of control promotes automation, allowing producers to maintain a standardize production and optimize costs (Appolloni et al., 2020).

The closed nature of vertical farms makes the system completely resilient to outside extreme climatic conditions and diseases, allowing a continuous yearly production free from pesticides and in any location. When combined with hydroponic systems, closed systems can help water savings, achieving a water use efficiency 30-50 times higher than open-air or greenhouse production. The possibility to cultivate on multiple levels reduces the space use and therefore the current global concern for agricultural land consumption. Lastly, production can take place close to consumption centres, which reduces transport and storage and related carbon footprints (Appolloni et al., 2020).

Vertical farms will need to become widely implemented to change the way supply chains function. This broader implementation is currently inhibited by the high investment costs (SOURCE), a comparatively high electricity use (Graamans et al., 2018) and a limited interest from consumers (Specht et al., 2019).

5.5.4 Aquaponics

Nutrient and energy efficiency can be increased by combining different production practices. Aquaponics combines aquaculture and hydroponic practices. Aquaponics is a promising farming technology, which requires a shift from specialised to integrated systems, re-using water and nutrients. It is a relatively new agricultural industry, which should be less dependent on primary energy and material inputs than conventional production systems (Stadler et al., 2017, Palm et al., 2018)).

The integration of aquaculture and hydroponics fits well with the principles of the circular economy, as it aims to re-use, recover and recycle nutrients, water and energy. Aquaponics is at the brink of commercialization, attracting investment (Palm et al., 2018). However, Stadler et al. (2017) found that profitable aquaponic farming is difficult. Aquaponic farms offer advantages by reducing costs for water, energy, fertiliser and waste. It still experiences serious competition from capital-intensive trading organisations, low prices of vegetables and imported fish fillets, as well as high prices for fodder, energy and labour. The system has to further reduce costs for investment and operation, increase productivity and/or deliver high valued fresh products. Currently the inherent cost reductions of aquaponics do not outweigh the related challenges and risks.

5.5.4 Smart farming & artificial intelligence

In the examples above the material aspects of the system are seen as drivers of innovation. Other approaches, such as 'smart' farming, may also prove valuable to improve the efficiency and the productivity of the sector. These cyber-physical systems note a direct connection between ecological production processes, information flows, and system optimization. In the circular bioeconomy the material flows can act as linking pins that connect different sectors (Pigford et al., 2018). Artificial intelligence (AI) can help people make better decisions and farm smarter (Di Vaio et al., 2020).

All stakeholders involved in the supply chain (i.e., farmers, processors, investors and so on) are considered as actors of business models founded on sustainability and responsibility themes. AI could help to fill the labour shortages and to reduce the environmental impacts from operations systems related to agri-food practices for all stakeholders. Di Vaio et al. (2020) lists various applications of AI technologies within 'smart' farming and the food industry: (1) AI for sorting food using optical sensor-based solutions with machine learning capabilities, saving time and money in production and improving the quality of the product; (2) Food industry supply optimization by testing and monitoring food products at every stage of the supply chain; (3) Ensuring hygiene standards by automatically monitoring workers and objects; and (4) Improving food preparation by using sensors to ensure that every ingredient (from meat to sauces and spices) is distributed in the expected doses. Hence, it is possible to say that technology has the potential to create a healthier and more thriving food industry for workers and consumers.

5.5.5 Blockchain

Blockchain technology has predominantly been analysed as the technology behind Bitcoin and other cryptocurrencies. One of the most relevant applications of the blockchain in the agri-food industry may be the production and supply chain quality control system. It allows consumers to trace and verify the history of every good from the production to the distribution to consumers (Tiscini, 2020). Specifically, the blockchain has the potential to simplify and integrate agricultural supply chains, enhance food safety, reduce risk in trade finance and promote inclusive trade, increase access to agricultural financial services, generate smarter market information and provide greater legal certainty to land-tenure systems (Tiscini, 2020).

Tiscini (2020) identified five opportunities for improving in the agri-food industry with blockchain: (1) Traceability through blockchain allows consumers to track issues concerning the product quality and safety throughout the supply chain in real time; (2) Labelling for national/international regulations or product features can be checked for fraud; (3) The use of agronomic, biological and mechanical inputs and certification of compliance with procedures and regulations can be tracked; (4) Financial transactions with reduced or eliminated risk of fraud, as the system will certify and enable the payment; and (5) Market data analysis is facilitated by the large amount of data generated and recorded through transactions.

De Besi et al. (2015) show that industries, research and innovations are oriented towards diverse applications of biotechnology. The diffusion of new ideas and technologies is not always quick and generally large-scale transformations of sectors take several decades (Klerkx et al., 2019). Effective measures need to be taken to properly set up the bioeconomy from a technological innovation perspective (Molyska et al., 2017):

1. Ensure public and private long-term support of basic as well as applied research to allow further innovation in agriculture (Molyska et al., 2017).

2. Supporting innovation-friendly legislation and communication with the public. Knowledge transfer needs to be intensified to unfold the added value of innovation (Molyska et al., 2017).
3. Encouraging and facilitating interdisciplinarity along the bioeconomy value chain. A variety of disciplines and industries are involved and need to interact and co-operate (Molyska et al., 2017, Pigford et al., 2018).

5.6 Product innovations

The bioeconomy is a new and essential paradigm for reducing our dependence on natural resources (Fernández et al., 2021) and has contributed to the search for new products that fit this agenda (for instance, through new niche-markets for bio-based products such as algae, etc) (Santeramo et al., 2017). The growing consumers' expectation for food quality, food safety and respect of the environment is offering new business opportunities or EU aquaculture producers who are willing to differentiate their products and serve specific markets (Santermo et al., 2017). The following section provides an overview of key characteristics and the associated environmental and economic impacts of several products that could play an important role in the bioeconomy.

5.6.1 Microalgae farming: Algae as a product and service

Despite being a comparatively new branch of agriculture, algae production is often considered to be a solution to many food security-related problems, such as land scarcity, climate change, inefficient and unsustainable fertilizer usage, as well as associated nutrient leakage and water pollution. Algae can be cultivated independently of arable land (Ullman et al., 2021). Key applications are the production of biomaterials, agriculture-related products, cosmetics, and biofuels, or the provision of services such as wastewater treatment and the fixation of industrial gases (Fernández et al., 2021).

Algae could fit in the ideal production system to produce biomass from certain waste streams, as it does not only need water and carbon-dioxide, but also a range of macronutrients, like nitrogen and phosphorous (Fernández et al., 2021). Especially in urban settings, the bioremediation of waste waters is of increasing importance, and it is thus one of the applications of microalgae which have sparked most interest. If integrated into the agricultural system in a circular manner, algae cultivation could decrease nutrient losses and greenhouse gas emissions, as well as provide green energy. For this to become a reality, algae production has to become cheaper, in order to compete with cheap, high-quantity products, such as oil (Ullman et al., 2021).

Currently, algae and algae-derived products are almost exclusively produced for high-value, low-volume markets and are far from being able to compete with cheap commodities such as plant-based proteins or fossil fuel (Ullman et al., 2021). The implementation of next-generation technologies is required for the targeted reduction of process waste, and energy and water consumption, across the entire microalgae value chain (Fernández et al., 2021). A sustainable "algae industry" could be an integral part of the future bioeconomy, enabling more resource-efficient food and fuel production and creating new products, companies, and jobs (Ullman et al., 2021).

5.6.2 Macroalgae farming: Seaweed for consumption

Seaweeds have traditionally been a major element of the diet in Asian countries, but less so in the West (Stévant et al., 2017). Seaweed biomass contains a large variety of phytochemical constituents and is a rich source of a wide range of bioactive products of potentially high market value. Relevant applications include (1) human food; (2) domestic animal and fish feed products; (3) fertilizer; (4) prebiotics; (5) cosmetics; (6) bioactive peptides; and (7) pharmaceuticals and nutraceuticals (Stévant et al., 2017, Torres et al., 2019). These applications are predicted to play an important role in bioeconomies based on seaweed cultivation (Stévant et al., 2017).

Seaweed farming has been considered an environmentally sustainable form of production. The crop sequesters carbon and removes inorganic compounds from water. The farm presented by Pereira et al. (2021) assimilated energy, nitrogen, phosphorus and carbon from the environment, sequestered carbon from the atmosphere, did not generate any pollution and the amount of sediment accumulated was low. Additional benefits are that all biomass-produced can be used, and thus, no waste is produced. Pereira et al. (2021) concluded that the farm may be not only environmentally, but also socially and economically sustainable: it generates work positions and income for local communities, promotes gender, racial and age inclusion and contributes to improve the local economy and food security.

Seaweed farming is found to be economically feasible, profitable, resilient, and to generate positive externalities. Economic indicators showed high efficiency in the use of investments, fast return on capital, and profitability. A high ratio between net income and initial investment (210%) and internal rate of return (190%) was achieved (Pereira et al., 2021). High-value products to be used in food, cosmetics as well as medical and pharmaceutical applications, are predicted to play an important role in creating value from (Norwegian) cultivated seaweed biomass (Stévant et al., 2017). A Norwegian study emphasizes that extensive cooperation between public authorities, the industry and research institutions is needed in order to develop a knowledge-based legal framework for a sustainable industry based on cultivated seaweed biomass (Stévant et al., 2017).

5.6.3 Insect farming: Protein from waste

The unsustainability of livestock production las led consumers, companies, organizations, and governments to consider entomophagy (eating insects1) as a more sustainable option. There are several benefits to entomophagy: insects have a high nutrient conversion efficiency, insects require fewer resources (water, land, labour) than traditional livestock, there are cost advantages attached to insects' short life cycle and the high reproduction rates, animal welfare is high, and nutrition levels are high (Madau et al., 2020, Skrivervik, 2020). Insects have high levels of protein, minerals, vitamins (A, B, C, D, E), as well as amino acids (Skrivervik, 2020). Edible insects are increasingly looking like a valid substitute to proteins of animal origin and waste treatment (Madau et al., 2020)

The environmental impact of insect production is considered low due to the limited requirement for arable land and water, low ecological cost, and high-quality protein provision (Madau et al., 2020). Additionally, several insects (such as grasshoppers, flies, and crickets) thrive on food waste that humans and traditional livestock cannot eat (Skriverik, 2020). Insects do not compete with humans for the same foods - as livestock do (grain and corn)-, i.e. insect farming does not take from the already limited resources on the planet but helps reduce food waste (Skriverik, 2020). In other words, processing edible insects or food and feed provides a natural missing link in designing a circular economy (Madau et al., 2020).

It is theorised that in the future insect farming would be much cheaper due to the ability to achieve a high productivity for land, water, energy, and feed, when compared with other meat producers (Madau et al., 2020). Furthermore, only limited investment costs are required (per unit of protein produced) and the required management and technology are simple and do not

1 We focus on the farming of insects, as it provides more benefits than those harvested in the wild (Nischalke et al., 2020).

require in-depth training. This allows for relatively fast returns on investment and high financial returns (Skiriverik, 2020). Madau et al. (2020) found that despite the increasing body of research, economic questions persist regarding insect use for food and feed. Consumer opinion will likely be a determinant factor.

5.7 Food losses and waste prevention, reduction and valorisation

Globally, around one third of food gets lost along the food supply chain (Godfray et al. 2010 In: Imbert, 2017). One of the UN's Sustainable Development Goals aims to half these losses at least. In terms of quantity, more than 50% of food waste is generated within the household level, while the other stages of the supply chain are contributing for a lower share: processing (19%), food service (12%), production (11%) and wholesale and retail (5%) (Stenmarck et al., 2016; Ojha et al. 2020).

This diversity of causes and relevance in supply chain's different stages calls for the development of a clear policy framework to identify priorities for optimising waste prevention strategies (Canali et al. 2017). The different options and strategies identified by literature can be grouped into three broad categories depending on the utilization or final destination of food: (1) prevention and reduction, (2) reuse and redistribution, as well as (3) recycling and valorisation. Prevention and reduction are often targeting consumers and other stakeholders through tailored awareness and communication campaigns. Reuse and redistribution are ensured through donations and redistribution activities facilitated and operated e. g. by food banks as well as by other community-based initiatives (Ojha et al. 2020). Recycling and valorisation are based on a variety of transformation processes integrating circular thinking into bioeconomy. Food losses and waste occur along the whole value chain from agricultural production to consumption (compare figure x). Generally, at food production a and processing stages, food losses are mainly related to external conditions such as adverse weather or pests, limited or outdated technology, poor storage infrastructures, marketing standards, etc. At the distribution and consumption stages, waste is primarily related to institutional, market, or behavioral factors, like unsold food, over preparation, or over serving (Ribeiro et al. 2017; Turon et al. 2014).

Canali et al. (2017) highlight the main drivers of food waste and grouped them into three different main contents (compare figure y). Technological limitations of the currently available techniques lead to a lack of product quality like perishability. These causes are mainly restricted to the primary production and contain reasons like improper storage conditions but also changing weather conditions and effects of climate change on the product quality. New plant breeding solutions and research are technological answers to these challenges. The second context of drivers for food waste are institutional. One the one hand they cover reasons that occur within single enterprises as well as due to their integration into the wider food chain. Moreover, broader economic and structural variables are taken into account. On the other hand, legislation and policy drive food waste. The prioritization of different political aims can lead to conflicting goals like shown in figure y. The social context sums up all drivers that are related to consumers' behaviour and lifestyle on macro-social, but also down to an individual level. The analysis covers the whole food supply chain and emphasises the variety of measures aiming to reduce food waste.

Contents		Grouping of Food Waste (FW) Drivers	selection of identified FW Drivers
Technological		T1—characteristics of food, and of its production and consumption, where technology has become limited	• Perishability of food staples • Changing environmental and weather conditions & climate change
		T2—collateral effects of modern technologies	• Fish by-catches • Processing methods (e.g. mechanical peeling of potatoes)
		T3—suboptimal use of, and mistakes in the use of modern technology	• Poor storage handling and conditions • Damages during transport • Cold chain inefficiencies
Institutional	Business Management & Economy	IBE1— management solutions operated within one single business unit	• Failures in sales forecasts of seasonal products • Inflexibility in portion size and assortment
		IBE2— management solutions coordinated among different FSC operators	• Return of unsold or damaged products for free • Possibility of last-minute cancelations of orders
		IBE3—broader economic and structural variables	• Lack of finance in developing countries, hindering the setting of facilities for proper conservation and processing of food staples
	Legislation and Policy	ILP1— agricultural policy & food quality and marketing standards	• Marketing standards for fruit and vegetables • overproduction related to government subsidies
		ILP2— food safety, consumer health and information, and animal welfare policies	• Differences among countries in the safety rules • Impracticability of obligation of relabeling or reprocessing food delivered with erroneous or misleading label information
		ILP3— waste and taxation policies and to other policies	• Lack of tax breaks and fiscal incentives on food donations
Social		S1— social dynamics that are not readily changeable	• Urbanization and related changing dietary habits and globalization of agri-food markets • Relatively high income level • Modern “busy” lifestyles;
		S2— consumers’ individual behaviors that are not readily changeable	• Selective behavior of consumers (aesthetical appearance of food and food packaging)
		S3— consumers’ individual behaviors that are modifiable through information and increased awareness	• Poor food skills and information • Misinterpretation of date labels • Practice of making bulk shopping or unplanned and “spontaneous” food purchases

Table 4: Sources of food losses and food waste along the supply chain

Conventional waste management of agricultural and food waste contains mainly incineration, landfills, composting and usage as animal feed. The incineration gets impeded due to the highwater content of food waste. The evaporation causes energy losses and the release of dioxins is a possible disadvantage (Ng et al., 2020). Landfills are still the most common practice. In the EU, 42% of the municipal solid waste is brought to landfills. Despite this fact, the environmental effects are quite serious. The high content of nutrients and water serves as a breeding ground for microorganisms which could result in bacterial contaminations and infectious diseases. The development of leachate and the emission of greenhouse gases are further impacts causing concerns. Composting can be an alternative to landfills, that even delivers useful bio-fertilizers. The application of this solution gets hindered by relatively high costs of this method (Maina et al., 2017; Ng et al.; 2020). Secondi, Principato and Mattia (2020) highlight the need for business investments in innovations and digital solutions in order to contribute to better manage and reduce food surplus and waste.

A different line of thoughts highlights the current situation of overproduction in Global North's industrialised countries and puts into question whether food production should still aim for high yields instead of health benefits. Berbel and Posadillo (2018) argue that the usage of by-products and waste from the food production such as the olive production as animal feed can provide many benefits. In developed countries functional food will play a great role due to the fact that the population is aging, and the food supply will exceed food demand. As a consequence, the quality and the healthiness of products will be more relevant. For feeding livestock, the former EU-28 has an overall self-sufficiency rate between 58% and 71%. The usage of by-products and waste from the olive production is considered as one example to become more independent from feed imports and to reduce feed costs, which is the most important livestock production cost factor.). Yet, it has to be mentioned that animal feed usage is strictly regulated and therefore more feasible for industrial by-products (Ng et al. 2020).

The usage of food waste for the food industry is related to a certain obstacle that many new products face. Even though there is a growing number of start-ups, consumer acceptance remains a difficulty, which needs to be overcome. The probability that consumers accept new products or reject them gets expressed in their tendency for neophobia (Tsimitri et al., 2018). Moreover, not only the product can arouse uneasiness but also the way it is produced can lead to resistance (food technology neophobia). The acceptance of novel food is often based on pre-consumption beliefs, the type of food, the level of familiarity as well as the cultural context and might lead to market failure. That is why the consideration of neophobia is important for product developers and marketers. The most important variable in a study from Tsimitri et al. (2018) was the age, followed by educational level, family income and number of children. Moreover, they examined the reasons that lead to a positive consumer decision, especially curiosity to try new products. If consumer decide against the product, they name reasons like a lack of health-promoting effects or further benefits. Additionally, the unwillingness to change their diets is another argument (Tsimitri et al. 2018).

A possible approach to classify the valorisation of by-products and wastes is the "bioeconomy value pyramid", which prefers the transformation into high value products over energetic usage (lowest value added, highest volume) (Berbel and Posadillo 2018).

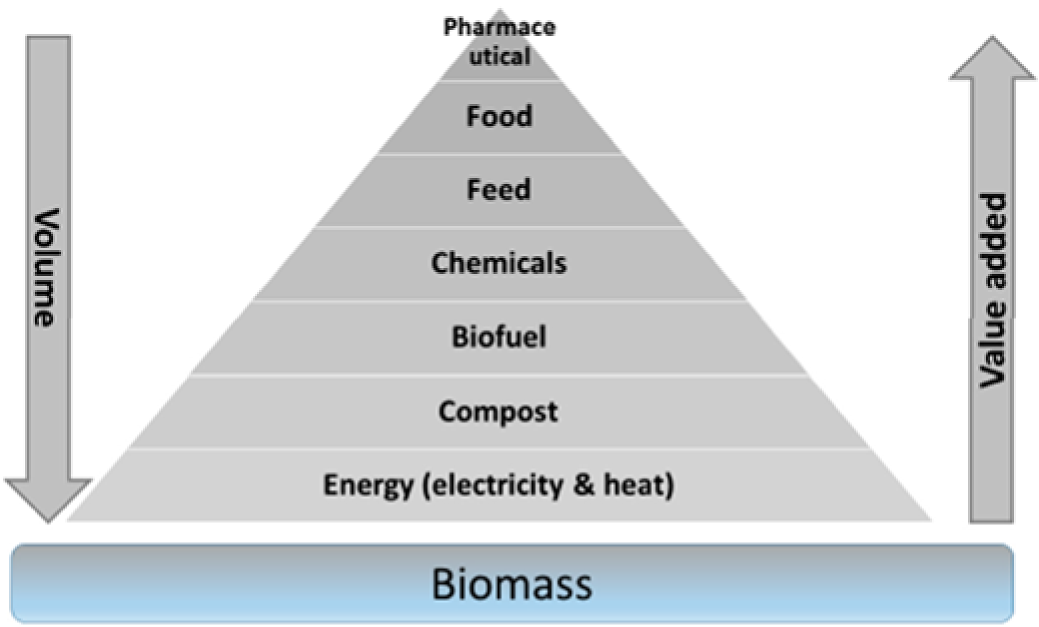

Figure 8 : Evaluation of solutions for food wastes (from Berbel and Posadillo, 2018)

With regard to the "bioeconomy value pyramid" great potential could arise from biorefineries. It is considered a key factor for the development towards circular economy (NG et al. 2020). Current only 9% of the global economy is considered circular (Overturf et al. 2020). The bioprocessing of different kinds of food waste employs different techniques for the extraction of high-value compounds out of food supply chain waste. Some examples are shown in table n.

Vegetable and fruits can serve as a raw material for the industry to extract bioactive components that are useful for the food or pharma industry (Maina et al., 2017; NG et al., 2020).

Examples for the extraction of high-value components from Food Supply Chain Waste (FSCW) due to bioprocessing:		
Kind of FSCW	Fruits and Vegetable	Bakery waste
Extraction of bioactive compounds and nutrients:	- polyphenols - carotenoids - vitamins - antioxidants - flavonoids - fibres - pectin	Used to formulate a nutrient-rich hydrolysate for the fungal strain Monascus purpureus
Use for	- additives in food industry - functional food - pharmaceutical application	Production of bio-colorants for the food and textile industry

Table 5 : Bioprocessing of food supply chain waste into valuable products (from Maina et al 2017 p. 20-21)

Examples of further studies show the plurality, heterogeneity, and complexity of food waste valorisation measures, like work on varlorising agro-industrial wastes in a circular bioeconomy approach (case of defatted rice bran) (Alexandri et al., 2020), coffee ground valorization (Zabaniotou and Kamaterou, 2018), bio-based plastics in fruit supply chains (Blanc et al., 2019) or monetarization of food waste reduction (Sedlmeier, Rombach and Bitsch, 2019),

The application of insects to make food waste usable for the production of human food, animal feed, fertiliser or secondary industrial compounds is a relatively new approach (SHIKHA et al., 2020). That allows to close the loop by making food waste a raw material for insect rearing. Even though there might be market-wise a great potential, there still exist some unanswered questions. Analyses on the environmental impact of insect rearing for commercial proposes have only started to be applied. Consequently, there is only little knowledge regarding a sustainable evaluation and some concerns regarding ecosystem imbalances if insects manage to escape from farms are mentioned by researchers. Therefore, it is still being debated whether insect processing allows to become an environmentally friendly or sustainably beneficial activity. Despite these uncertainties, insects may offer a high food conversion rate and simultaneously need low inputs in form of land, water and feed compared to traditional animal keeping systems. Nevertheless, there are regulatory restrictions made by the EU. The substrate has to be eligible as feed, therefore manure or catering waste that could contain animal by-products, are forbidden. Moreover, the content of the food waste and especially the moisture content and the microbial safety are some important parameters that have to considered. That is why a treatment of the waste like homogenisation and pre-fermentation are helpful to avoid spoil and potential development of pathogens and toxins. Other problems of the insect industry concern the large amount of organic waste that stands at the end of the production. The application as fertiliser could derive as a suitable solution. Additionally, the recovery of macromolecules from insects has a strong need for chemical solvents, which is not only a problem with regard to consumer acceptance but also inimical for the environment.

6. Synthesis

The report presents the findings of a structured literature review on business models in the food bioeconomy sector based on innovation and sustainability.

This literature review on state-of-the-art business models in the food bioeconomy sector focused on innovation and sustainability is based on the PRISMA method aiming to conduct and report systematic reviews and meta-analyses on a specific topic (Moher et al., 2009). The review made use of the Scopus and Web of Science database and is limited to published papers from 2010 to present within the fields "article title", "abstract" and "keywords". Search term combinations from the topics concerned where used in 51 combinations. Starting from a list of more than 6,000 contributions, the PRISMA method allowed for a stepwise filter process to, firstly, 629 documents, secondly, 275 documents, and, finally, 122 papers considered suitable for the review purpose.

Based on the research fields of the papers selected based on the PRISMA method, relevant topics of the food bioeconomy and their underlying business models are emphasized on, namely urban and peri-urban agriculture, Alternative Food Networks, technological innovations (plant breeding, building-integrated rooftop greenhouses, vertical farming, aquaponics, smart farming & AI, block chain), product innovations (algae, insects), and food waste valorisation.

6.1 The bioeconomy: description and potential

The bioeconomy is a sector centred around biomass and biological resources (PANNICKE et al. 2015; LÖDDING et al. 2017). It is defined as an economy where the basic blocks for materials, chemicals and energy are derived from renewable biological resources (McCormick and Kautto, 2013). This broad definition leads to an integration in numerous economic sectors (Lainez et al., 2018) aiming for circular and more sustainable economies. Benefits from the development of circularity-oriented bioeconomy are potentially massive compared to linear, fossil fuel-based economies. The societal increased interest in sustainability provides the basis for innovative, sustainable, and circular thinking and behaviour. Therefore, the bioeconomy can contribute to multiple societal challenges in the coming years: food security, climate change, sustainable resource management, private companies' competitiveness, job creation and the high dependence on non-renewable, fossil fuel-based resources.

6.2 Business models in the bioeconomy

Business models structure "how value is created for the customers and how value is captured for the company and its stakeholders" (Henriksen et al., 2012: 31), how firms do business on a system level – simply, how companies carry out their business (Henriksen et al., 2012): Business models build the DNA of a company. The Business Model Canvas (BMC) is a strategic management tool which provides helpful overviews of companies to a) emphasize key success factors, b) detect barriers, c) compare competitors and d) generate business ideas and innovations (s. OSTERWALDER, A. & PIGNEUR, Y., 2010). The business infrastructure is composed of the key resources, key activities and key partners, while the financial viability is summarized with the two building blocks revenue streams and cost structure. Together with the growing relevance of circular-oriented bioeconomy and further progress towards sustainability, innovation and resilience, the one-layered BMC focusing on economics has been developed further, resulting in different sustainability-oriented business model tools allowing companies to respond to economic, social and environmental challenges. In the bioeconomy, business models are innovative and associate profit, social and environment positive impacts. Value, key concept on business model in bioeconomy includes shared value not only for the firm but also shared by the society, the employees. The main objective for the firm is to be competitive without depleting natural resources in two ways: 1- decreasing the consumption of natural resources 2- allowing their regeneration.

6.3 Disrupting the bioeconomy through innovation

Innovations, which are a key aspect for business success, happen incrementally as well as disruptively – also in the food system (Kuokkanen, Uusitalo and Koistinen, 2019; Lestari, Rodhiyah and Najah, 2020). Disruptive innovations opened up from a primarily technological and product focus to entrepreneurial and citizen involvement allowing access to complete new markets and emergence of new business models (Kuokkanen, Uusitalo and Koistinen, 2019). However, papers primarily focus on product and/or technological innovations, while business model innovations are largely ignored (Ulvenblad et al., 2014). Instead, changing expectations and demands of users provide the basis for new business models and value offerings.

Business model innovations in the food bioeconomy play an important role for food start-ups at any stage of circular value chains (Franceschelli, Santoro and Candelo, 2018). Potential (disruptive) innovations in the food bioeconomy are: alternative protein-source products, plant-based and cell-based meat; alternative distribution chains (online, e-commerce, food assemblies, …); production systems attributed with high sustainability potentials (aquaponics, permaculture, …); community-oriented food and sharing economy (Alternative Food Networks, Community Supported Agriculture, …); urban agriculture; new localities (vertical farming, …); technological innovations (precision agriculture, aquaponics, smart and digital farming); but also forest for food, genomics innovations, etc. (Geels, 2008; Jimenez-Sanchez, 2015 ; Solberg et al., 2016; Chamberlain ; Ashlee-Ann et al., 2018; Kuokkanen et al., 2019; Chen et al., 2020 ; Broad, 2020 ; Daar and Meinhold, 2020). They have the potential to create sustainability-oriented bioeconomies, circular economies, or local place-based food systems (Borrello et al., 2016; Hermans, 2018; Rossi, 2017). Regardless of the position in the value chain, actors have to consider consumption demand and product quality. Innovations for food sector's sustainable development comprise both, retro and forward-looking innovation (Leon-Bravo et al., 2019). Forward-looking innovation is a redesign of business models oriented towards sustainability (new products, reconfiguration of supply chain, new market segments), which is predominantly considered by comparable small businesses.

The retro innovation sets a focus on traditional processes. Sustainable innovations in the food sector are named to be winning strategies to gain business success. Overall, food system business model innovations have the potential to boost competitiveness and sustainability simultaneously, mainly by means of new value proposition and business management methods (Franceschelli, Santoro and Candelo, 2018). In the last decade, the surge of circular economy, sustainability, and bioeconomy have led companies and organizations to innovate their business models (Donner et al., 2021).

6.4 *Technological and product innovation for the bioeconomy*

Recent trends unveiled the multifaceted opportunities in urban agriculture for sustainable business model innovation (SBMI) for improving the circular bioeconomy in the urban and peri-urban context. Circular and innovative BMs are widely recognized as pivotal in enhancing the sustainability impacts of urban agriculture activities and organic food towards the bioeconomy. Technological innovation has the potential to be disruptive and transformative in many ways. It may have biophysical, economic and social impacts on food and nutrition security, as well as on the ways in which agricultural production systems are designed and operated (Klerkx et al., 2019).

In particular, technological innovations hold major transformative potential for agriculture. Operational concepts include vertical farming, rooftop farming, digital agriculture, circular agriculture and aquaponics (Klerkx et al., 2019, Appolloni et al., 2020). Developing technologies are gene editing, synthetic food production, cultured meat or cellular agriculture nanotechnology, microalgae bioreactors, drones, internet of things, robotics and sensors connected to precision farming technology, 3D food printing, artificial intelligence and machine learning, and blockchain (Klerkx et al., 2019). These alternative agricultural technologies have the potential for enhancing the bioeconomy and the circular economy, or local place-based food systems (Pigford, et al.,2018). The bioeconomy is a new and essential paradigm for reducing our dependence on natural resources (Fernández et al., 2021) and has contributed to the search for new products that fit this agenda (for instance, through new niche-markets for bio-based products) (Santeramo et al., 2017). These product innovations include microalgae farming, macro algae, and insect farming.

Finally, the (food) waste management sector is of essential importance, as it enables a closed-loop economy by reusing residual and waste materials ain the highest possible quality (BMBF and BMEL 2014). The usage of food waste for the food industry is related to a certain obstacle that many new products face. A possible approach to classify the valorisation of by-products and wastes is the “bioeconomy value pyramid”, which prefers the transformation into high value products over energetic usage (lowest value added, highest volume) (Berbel and Posadillo, 2018).

Even though there is a growing number of start-ups and novel products, consumer acceptance remains a challenge. The probability that consumers accept or reject new products ois expressed in their neophobia (Tsimitri et al., 2018), an important field for future studies.

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