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## Article

# Innovative Business Models for a Sustainable Circular Bioeconomy in the French Agrifood Domain

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**Abstract:** In recent years, the circular economy and the bioeconomy have increasingly been developed in France, driven by public policies. In this article, innovative circular bioeconomy business models in the French agrifood domain are studied concerning main drivers, business model elements, circular economy principles, enablers and barriers, and sustainability benefits. The study is based on an online review and analysis of 44 local, collaborative and small-scale initiatives. It appears that the strategies of the businesses are based on the seven circular economy pillars laid out by the French Agency for the Environment and Ecological Transition, mostly recycling, sustainable procurement, and industrial and territorial ecology. Geographical embeddedness and the relational proximity of actors are other crucial factors that play a role in the success of these business models, next to pro-environmental consumer trends and local public support. The outcomes further reveal that all three sustainability dimensions are integrally considered in France, with environmental and social dimensions slightly prominent above the economic one. The application of the game concept and its seven building blocks (time, playing fields, pieces, moves, players, rules, wins or losses) allows this study to demonstrate the essential elements of emerging business models within bioeconomy systems, their dynamic interrelations and the need for full policy attention.

**Keywords:** circular economy; bioeconomy; business models; sustainability; agrifood sector; France



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## 1. Introduction

The bioeconomy has been defined by the European Commission [1] as the production and conversion of renewable biological resources from agriculture, forestry and aquaculture into novel value-added products such as pharmaceuticals, food, animal feed, biobased materials or bioenergy. The bioeconomy is supposed to respond to global challenges such as food security, climate change, resource scarcity, and environmental pressure [2]. Hence, the expectations from the bioeconomy, in general, are high; more than 50 countries and international organizations worldwide are implementing policies or strategies for promoting the transition to a bioeconomy [3,4]. However, there seems to be little consensus concerning what bioeconomy exactly implies [5], and controversies exist regarding its implementation pathways [6,7]. Some authors highlight the potential negative consequences or trade-offs, such as increased pressure on land, water and natural ecosystems, or agricultural intensification [8,9]. As such, the bioeconomy is not sustainable, and there are risks to continuing to follow linear approaches if circular economy principles are not explicitly considered [10,11]. The circular economy aims at resource efficiency by keeping the value of products, materials and resources for as long as possible, and minimizing the generation of waste [12]. The European Commission updated its bioeconomy strategy in 2018 by integrating the concepts of sustainability and circularity [13]. This, for example, emerges in the new Circular Bio-based Economy Joint Undertaking (CBE-JU; <https://www.cbe.europa.eu/>, accessed on 8 January 2023), which is becoming even more relevant since the looming “availability

gap in biomass” could be as big as 40–70% by 2050 [14]. The circular bioeconomy can be viewed as a concept that aims to address the debate on how to solve sustainability challenges [15,16] and this future biomass gap.

In France, the Paris Conference on Climate Change (COP21) in 2015 acknowledged the importance of global food security and the vulnerability of food production systems, and the need for more resource-efficient and resilient production and consumption systems. The conference agreement was the basis for the French Sustainable Development Strategy 2015–2018 and law n° 2015-992 for Energy Transition and Green Growth. To respond better to the environmental and social challenges and in line with the European Commission Bioeconomy policy, a national bioeconomy strategy was developed and adopted in 2017, followed by an action plan in 2018. Agriculture plays a key role in the French economy, as the country is the leading European agricultural producer and the third largest exporter after The Netherlands and Germany. The agrifood sector significantly contributes to its socio-economic dynamics, with 51% of its mainland cultivated, revenues of EUR 72.8 bn annually from agriculture, and revenues of EUR 169 bn from food production [17]. The production and manufacture of food are also deeply rooted in the culture and history of France, especially at local and regional scales, as witnessed by the high number of protected geographical indications and regional brands [18] (<https://www.inao.gouv.fr/eng/Official-signs-identifying-quality-and-origin>, accessed on 20 December 2022). Therefore, a local territorial approach for the collection and valorization of all types of bioresources, for food and non-food applications, is often adequate and encouraged by regional public policies.

The French bioeconomy approach is also characterized as being participatory because it is based on multi-actor collaborations of different stakeholders (enterprises, public actors, NGOs, academics, and citizens) involved in the decision-making processes and implementation of projects [17]. The collaborative multi-stakeholder approach also served to establish the 2017–2018 Roadmap for the Circular Economy in France. The French Agency for the Environment and Ecological Transition, ADEME (l’Agence de l’Environnement et de la Maîtrise de l’Energie), provided valuable input [19] by dividing the different action domains of the circular economy into seven interrelated pillars. These pillars are grouped into three phases, production, consumption and end-of-life, as follows: (i) sustainable procurement, eco-design, industrial and territorial ecology, and functional economy, which are mainly considered in the production phase; (ii) responsible consumption and the extension of the life of products, during the consumption phase; and (iii) recycling and energy recovery, at the end-of-life phase.

The most important legal instrument resulting from the Circular Economy roadmap is the law against Waste and for a Circular Economy (AGEC law n° 2020-105), which was established in 2020. It aims to eliminate waste and adopt more circular practices, by banning the destruction of unsold goods (as already introduced for edible unsold food products in the GAROT law n° 2016-138), completely phasing out single-use plastic materials for packaging by 2040, encouraging repair products, and reinforcing consumer information. The law also supports enterprises that incorporate principles such as democracy, solidarity and social utility (as earlier outlined in law n° 2014-856 for a social and solidary economy). Hence, business models that are based on valorizing local resources, and following territorial, collective and/or social approaches now become important in the transition to a circular bioeconomy in France [20,21].

The academic literature on circular business models has been significantly growing since 2015 [22,23]. A circular business model links the different concepts of sustainability, circular economy and resource efficiency [24]. It aims to contribute to an economic system that is more sustainable and regenerative by nature [25]. Hence, in contrast to a traditional business model, the objective of a circular business model is not only economic performance, but also closing energy and material loops, while ensuring firms’ viability in all industrial sectors [26]. Business model research in the bioeconomy domain is still underrepresented and is often linked to the wider circular economy [27–29]. Bioeconomy business models can be considered innovative management tools for developing new products or services

in particular targeting biomass instead of fossil-based resources via recycling or cascading approaches [30].

Combining the circular economy and bioeconomy provides novel business opportunities, supported by consumers' demands for local, green and recycled products [31]. These so-called circular bioeconomy business models still face a number of barriers and risks, such as a dependence on public subsidies and adequate policies and laws, high investment costs, a need for cooperation and collaboration, or price competitiveness for bio-based products [32–35].

Therefore, circular bioeconomy business models need innovative approaches and tools [36–40]. They should not only focus on technological, research and knowledge-based innovations, but also on organizational and/or social innovations, for being able to deal with various challenges and handle heterogeneous biomass resources [39]. The innovation challenge can be addressed by experimentation using iterative approaches with stakeholders, including suppliers, customers or consumers. This permits businesses to explore different options for the adaptation of the business model elements [40].

The importance of interactions and the engagement of stakeholders in sustainable, circular and bioeconomy business models has often been stressed in academic literature [35,41–44]. Some authors [41] highlight that the performance of business models depends on the exchange of experiences and knowledge between diverse stakeholders of the quadruple helix (government, industry, academia, and civil society). For example, cooperation with researchers can allow enterprises to apply jointly for funding; associations and cooperatives can give technical support [35]. External stakeholders can advise businesses on how to report the sustainability outcomes of their activities, via well-defined criteria [42]. In particular, public authorities and civil society influence socio-cultural perceptions of the circular bioeconomy [43]. Next, stakeholders can also simultaneously contribute to and benefit from the value (co-)creation process of business models, especially those engaged in sustainability or circularity [44].

The overall aim of this article is to explore what kind of innovative circular bioeconomy business models exist within the French agrifood domain that efficiently exploit bioresources while contributing to reducing the future biomass gap. A particular focus will be on territorial, collaborative, small-scale and/or social approaches. Our research questions are as follows: What are the main drivers, business model elements and valorization strategies of local, collaborative and small circular bioeconomy business initiatives in France? What are their enablers and barriers? How do they contribute to sustainability? These questions are based on the hypothesis that diverse business model types with different strategies are needed to advance the transition to a sustainable circular bioeconomy.

To answer the research questions, an online review of 44 initiatives has been carried out. To the best of our knowledge, such a review has not yet been conducted in France, where the literature has rather focused on single large-scale biorefinery and biotechnology clusters such as the pole IAR in Northern France or the Toulouse white biotechnology center [45–47]. More specifically, the aim is to understand the main drivers, business model elements (resources, partnerships, activities, value propositions), circular economy principles, enablers and barriers, and economic, environmental and/or social sustainability benefits of the researched circular bioeconomy business models.

## 2. Methodology

In accordance with our overall research aim, data were collected via an online search and review of several circular bioeconomy business initiatives in the French agrifood sector. As a database, the francophone internet platform '[www.economiecirculaire.org](http://www.economiecirculaire.org)' was used to identify the enterprises and their main characteristics. The websites of the initiatives were additionally consulted for further information. The [economiecirculaire.org](http://www.economiecirculaire.org) platform is the reference used in relation to the country's circular economy domain, thus providing broad information for public actors, professionals and experts in this field (<https://www.economiecirculaire.org/static/a-propos.html>, accessed on 8 December 2022).

It has been created by the French National Institute of Circular Economy and the International Centre for Resources and Innovation for Sustainable Development (CIRIDD). Its objective is to offer a common space for knowledge creation, networking and exchange between various actors from different sectors in the circular economy. It is linked to several other regional platforms, from metropolitan France and Québec in Canada. Circular economy initiatives are invited to present themselves on the platform, following a standardized scheme encompassing the objective, history and development of the initiative, geographical location, partners, resources used, enablers and barriers, and benefits provided.

As a filter for the search, the keywords ‘agriculture, alimentation (food)’ were used. In total, 186 circular economy initiatives were displayed for agriculture, and 248 for food. In the further selection, solely initiatives from France and only the ones with a clear focus on the circular economy and closing-loop principles were included. Next, the following criteria were used for exclusion: double-listed initiatives, initiatives that did not reveal any agrifood activities, very broad (public or collective territorial) initiatives with the mobilization of actors for the promotion of circular economy only, business models that were not yet implemented, general or biowaste collection initiatives without any biomass valorization, and cases targeting organic agriculture or local food sales without circularity activities.

Finally, 44 circular bioeconomy business model initiatives from the agrifood sector were selected for analysis. For these initiatives, the different data found on the platform and on the websites of the companies were downloaded and saved as pdf files. Data were treated via a qualitative content analysis, which allows the description and interpretation of textual data in order to make ‘replicable and valid inferences from texts’ [48], and to identify themes and patterns [49,50]. The data sources were coded for each initiative regarding its general type of business model, geographical location (region), business drivers, business elements, economic, social and/or environmental benefits, and enablers and barriers. The key data of each initiative were synthesized in a table according to the following main criteria (cf. Appendix A):

- The type of business model;
- The business drivers and the date when it started its circular economy activities;
- The geographical location (region);
- The business model elements, including the type of resources used, the key partners or clients, the activities and valorization pathways leading to the main value proposition;
- The circular economy principles applied according to the ADEME pillars and as indicated by the business itself;
- The enablers and barriers (as indicated online by the business itself);
- The sustainability benefits (as indicated online by the business itself).

The data were then analyzed and presented according to the conceptual scheme of a game developed by De Vries et al. [51,52], which describes the bioeconomy or food systems in terms of the time (the origin of circular bioeconomy activity, its development and characteristics of evolution), the contexts (the playing fields), the resources (the pieces), the resource handling in terms of activities and value propositions (the moves), the actors (the players) and their interactions, the enablers and barriers (the rules), and the sustainable or unsustainable outcomes (the wins or loses). This scheme was chosen because it allows an understanding of not only the main activities and value propositions of a business model, but also its interactions with other players from the value chain and from the larger (food or bioeconomy) system, the context in which new business models emerge and act, and the outcomes in time.

### 3. Results

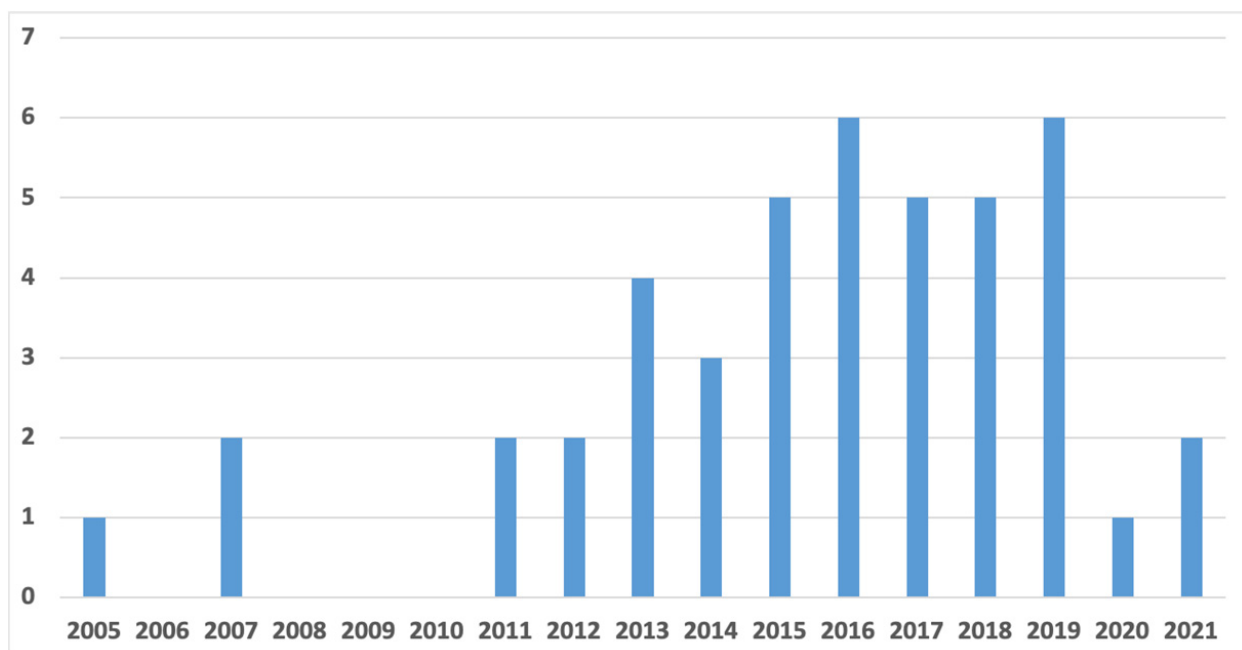
Results are presented according to the game concept introduced in the Section 2; hence, the subsections are as follows: the type, origin and drivers of the business activities (Section 3.1), their playing fields or contexts (Section 3.2), the key resources and their handling activities to obtain value propositions (Section 3.3), the key actors and their

interactions (Section 3.4), the enablers and barriers (Section 3.5), and the (un)sustainability outcomes (Section 3.6).

### 3.1. Business Model Types, Origin and Drivers

Different types of business models were found, mostly micro-firms (22 out of the 44 cases), small (12 cases) and medium-sized enterprises (8 cases), and only two large companies. Among them, there are seven associations, which have the main advantages of not needing to have registered capital and being flexible in hiring volunteers. There are also two social and community-oriented enterprises (cases number 30, 44), two industrial ecology parks (cases 22, 27), two public–private partnership projects (21, 28), one cooperative (6), one farmer (1), one brewery (2), one series of shops selling food products in bulk without packaging (12), one restaurant (19), and one bakery (10).

As illustrated in Figure 1, most of the enterprises (41 out of 44) have started their circular bioeconomy (waste and by-product valorization) activities in the past decade, which corresponds to the increasing public attention to the circular economy in this period.

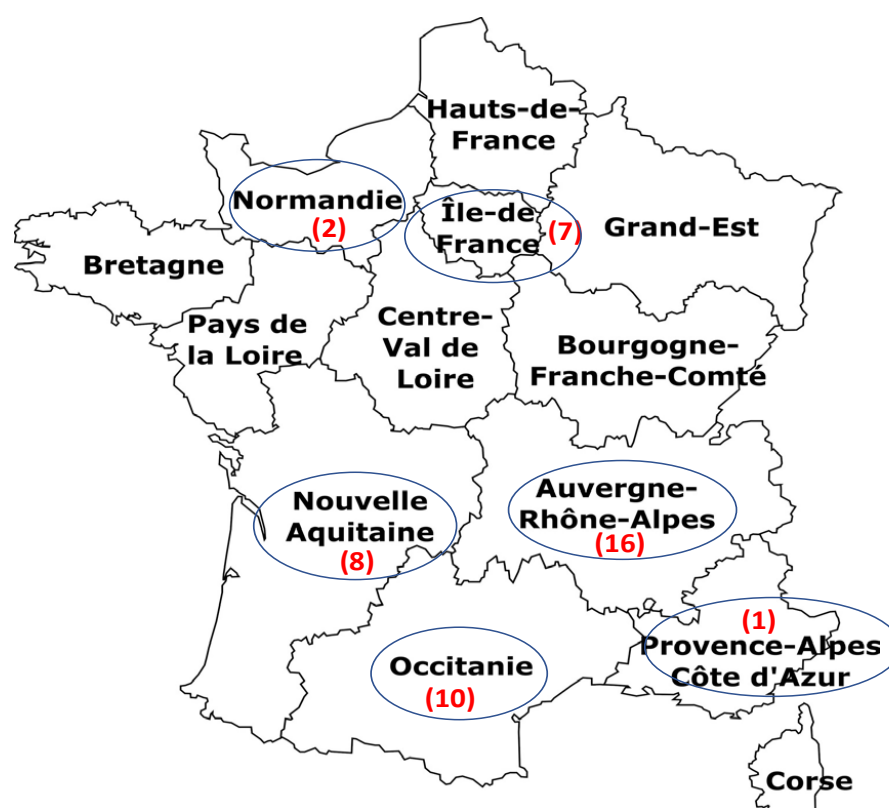


**Figure 1.** Number of circular bioeconomy initiatives started per year (source: own design).

The circular bioeconomy business activities are motivated by diverse and sometimes multiple reasons. Six groups of drivers could be identified. The most important driver is environmental responsibility and concern. Considering the often still unused or under-exploited waste and by-product quantities, actors wish to fight against these losses. Many enterprises see the (economic) value behind these types of bioresources as a new business opportunity and motivation to act. Another important reason for engaging in agrifood waste and by-product valorization is to contribute to local sustainable development, with the creation of economic, environmental and/or social value via new jobs or the delivery of food aid. Other enterprises indicate as driver product or process innovation, looking for new markets, high-quality biobased products, or novel solutions for co-products via technological innovations. Seeking cooperation based on local symbiosis, thanks to synergy effects and jointly and newly developed value chains, is also mentioned. Finally, the need for a diversification of business activities can play a role in remaining competitive.

### 3.2. The Playing Fields

In Figure 2, the respective regions of origin are depicted. The overwhelming majority of initiatives found are located in the South of France. In total, 16 out of the 44 businesses are settled within Auvergne-Rhône-Alpes, 10 in Occitanie, 8 in Nouvelle-Aquitaine, 7 in Île-de-France, 2 in Normandie and 1 in Provence-Alpes Côte-d'Azur. Thus, only 6 of the 13 metropolitan regions in France are represented. The reason that these regions in particular are presented has to do with the fact that the *economicirculaire.org* platform—used for the search—is linked to their regional circular economy platforms (except Nouvelle-Aquitaine). Roughly half of the enterprises are located in rural areas. They mostly manage large amounts of agricultural waste and by-products, often for biogas production. The other enterprises are active in an urban or periurban environment, especially the ones dealing with food redistribution, urban biowaste valorization into compost, or co-products from breweries.



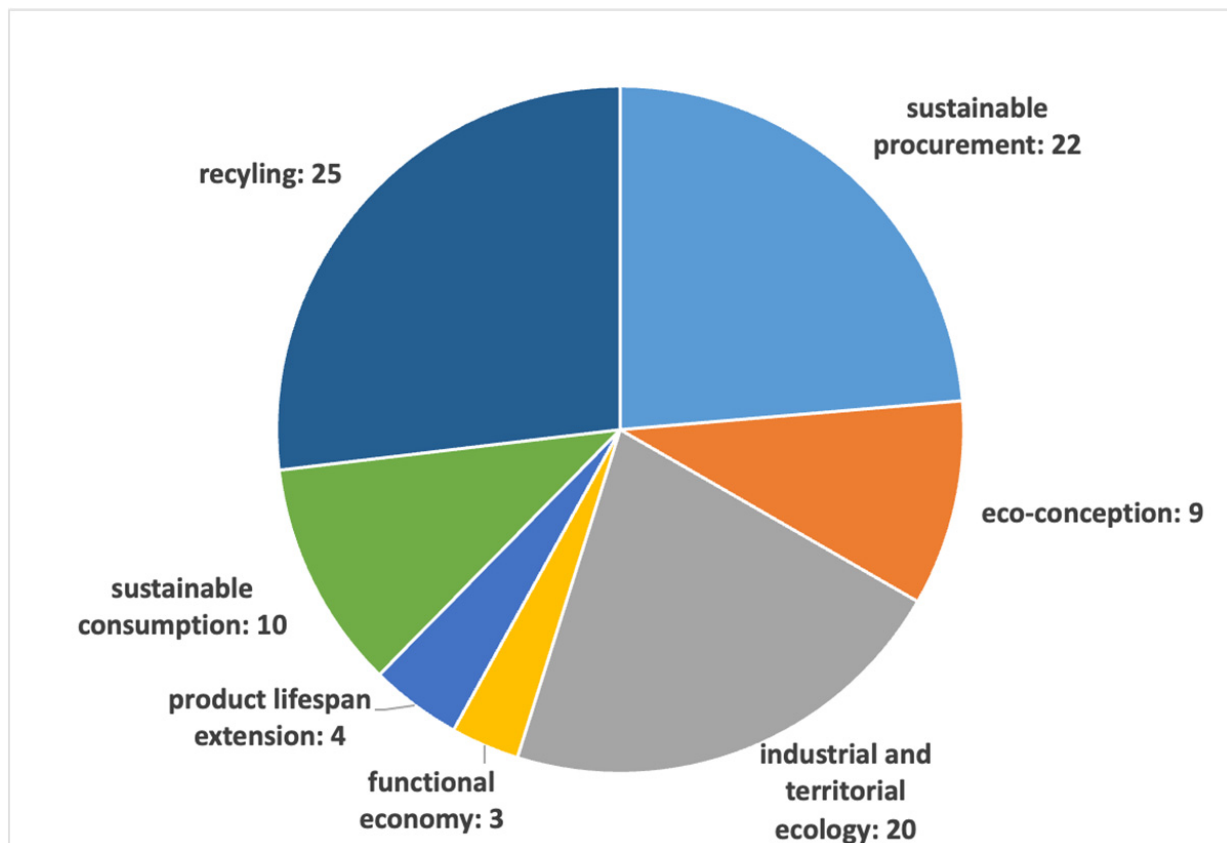
**Figure 2.** Regional repartition of the number of circular economy initiatives (source: own design).

### 3.3. Resources, Activities and Value Propositions

The key bioresources used are losses, waste and by-products that originate from different stages of the agrifood supply chain. Agricultural waste and by-products are the residues that are not further processed into food or feed [53], and food losses and waste refer to the decrease in edible food mass throughout the supply chain [2]. The losses mainly stem from the primary agricultural production and distribution, the by-products from food processing, and the waste from the food retailing and consumption stages. Among these resources, there are, e.g., unsold foodstuffs such as bread, fruit and vegetables, by-products from wine, fish, cheese, cereals, coffee and beer processing, or mixed (urban) food waste. Other by-products originate from animal manure, medical plants, used oils or sheep wool.

Accordingly, the most common activity in the cases is the collection and valorization of the diverse biomass resources into new products (38 cases in total), whereby some companies additionally offer consultancy or training, mainly to professionals (cases 8, 22, 29, 42). All companies apply one or several circular principles in their activities. However,

a few cases are not bioeconomy-related in a strict sense, as they do not transform biomass into new products; case 12, for example, is focused on sales of unpacked food products, case 9, on the collection and reuse of drink bottles, and cases 15, 19 and 44, on the collection and redistribution of unsold surplus, ugly or expired food products. The applied circular principles according to the seven pillars of ADEME are presented in Figure 3. They show that most of the companies (25) are recycling biomass, followed by sustainable procurement (22), and industrial and territorial ecology projects (20). Ten initiatives are oriented toward sustainable consumption and nine toward eco-conception. Only four apply a product lifespan extension and only three apply functional economy principles (defined as ‘selling the use of a product, not the product itself’), which is not surprising as we are dealing here with organic matter.



**Figure 3.** Circular economy principles applied by initiatives, according to the 7 pillars of ADEME (source: own design).

The value proposition constitutes the main products and/or services offered by a company to its customers (B2B) or consumers (B2C). Most of the initiatives are converting biomass into biofuels, biogas, electricity, or heat (14 cases in total). Equally, compost or biofertilizers are produced (14 cases). Many businesses create added value by proposing new food products or ingredients, animal feed or beverages, such as soups, juices, cookies, beer, or milk powder (9 cases). This is followed by a conversion into biomaterials for diverse uses, such as leather (cases 18, 31), insulation material for the construction sector (case 20), sheep wool for bags (case 24), material for roofs (case 27), or edible tableware (case 35).

### 3.4. Actors and Their Interactions

Partnerships of actors are diverse and vary among the initiatives studied. Many enterprises collaborate with public partners, such as local municipalities, regional gov-



ernments, development agencies and chambers of trade, ADEME (French Agency for the Environment and Ecological Transition), or even a tourism office (case 43). Other initiatives are based on private–private partnerships, either with big service companies for waste collection (cases 3, 32), large market-sector-oriented industrial partners (case 6 with an oil company, case 16 with an enterprise for animal feed, case 31 with the leather industry), or are composed of nearby smaller businesses, such as farms, restaurants, bakeries, breweries, hospitals, gardens or supermarkets (this concerns the cases focusing on food redistribution, compost or biogas, such as 1, 2, 5, 10, 15, 17, 20). A smaller third group of partners involves research institutes (cases 4, 21, 22, 27, 42). This type of collaboration occurs when more scientific evidence-based high value-added products and ingredients are developed, and in research or industrial and territorial ecology projects. Some businesses directly address citizens and consumers (cases 1, 12, 33, 39), especially when dealing with local composting. Partnerships with strategic consulting (case 7) or technical support (case 41) were only observed in two cases. Finally, it is worth mentioning that in more than half of the cases (25 in total), partnerships and interactions between multiple actors from the upstream and the downstream of different chains and from the local and regional systems are established.

### 3.5. Enablers and Barriers

Online, the businesses themselves have mentioned the enablers and barriers. We have grouped them according to five existing categories of factors defined in previous research on European and international circular business models valorizing agricultural waste and by-products [33]: economic-financial and marketing, technical and logistic, organizational and spatial, institutional and legal, and environmental–social and cultural factors. The factors are displayed in Table 1.

**Table 1.** Enablers and barriers (source: own creation).

	Enablers	Barriers
Organizational and spatial	<ul style="list-style-type: none"> <li>- proximity and long-term partnership</li> <li>- waste and by-product collection in the neighborhood</li> <li>- proximity, confidence, openness and engagement of actors</li> <li>- collective management of waste</li> <li>- complementary skills</li> <li>- territorial embeddedness</li> <li>- public-private partnerships</li> <li>- collaboration, networks, partners</li> <li>- knowledge of retailers</li> <li>- land-use control</li> <li>- direct local production by producers without an intermediary</li> </ul>	<ul style="list-style-type: none"> <li>- recruitment in rural area</li> <li>- insufficient space in city</li> <li>- difficult to get access to land for composters</li> </ul>

Table 1. Cont.

	Enablers	Barriers
Environmental, social and cultural	<ul style="list-style-type: none"> <li>- media communication</li> <li>- increasing awareness of the environmental problems</li> <li>- 'Made in France'</li> <li>- support of local communities</li> <li>- knowledge of clients' needs</li> <li>- loyalty of consumers</li> <li>- a curiosity of the public towards new products</li> <li>- the trend for waste valorization and agro-ecology</li> </ul>	<ul style="list-style-type: none"> <li>- need for new skills (language)</li> <li>- not everybody is sensitive for the waste topic</li> <li>- acceptability</li> <li>- the COVID pandemic</li> </ul>
Technical and logistic	<ul style="list-style-type: none"> <li>- scientific and private company support</li> <li>- well-established logistics</li> <li>- central positioning of the firm</li> <li>- availability &amp; quality of by-products</li> <li>- public support and training</li> </ul>	<ul style="list-style-type: none"> <li>- fluctuation of waste quantities</li> <li>- competition for food surplus resources</li> <li>- lack of technologies</li> <li>- logistics needed for collection</li> <li>- time needed for R&amp;D</li> <li>- time needed for composting</li> <li>- quality requirements</li> <li>- limited production capacity</li> <li>- process upscaling</li> </ul>
Economic-financial and marketing	<ul style="list-style-type: none"> <li>- financial support</li> <li>- public financing</li> <li>- financing capacity</li> <li>- participation in trade fairs for promotion</li> </ul>	<ul style="list-style-type: none"> <li>- financing</li> <li>- need to know which are support options</li> <li>- marketing</li> <li>- investment costs</li> <li>- transition from free-of-charge to payable service</li> <li>- market price dependence</li> </ul>
Institutional and legal	<ul style="list-style-type: none"> <li>- public laws for energy transition and waste separation</li> <li>- laws pushing professionals to change</li> <li>- public regulation</li> </ul>	<ul style="list-style-type: none"> <li>- fiscal constraints</li> <li>- reglementary and administrative barriers</li> </ul>

In the French cases studied, the most important enablers are organizational and spatial in nature, with an emphasis on the geographical proximity of actors, local cooperation and resource handling. Next, environmental, social and cultural factors are emerging, including local institutional support, general environmental trends and consumer behavior. Among the barriers, technical and logistic challenges are dominant, as well as economic, financial and marketing factors.

### 3.6. Sustainability Outcomes

All the business models studied indicate on their websites how they contribute to sustainable solutions via their business activities and value propositions. These statements correspond to one or multiple sustainability dimensions—economic, environmental, and social. Especially concerning the environmental impact, the benefits are expressed in very concrete numbers. Some illustrative examples are listed in Table 2.

**Table 2.** Some examples of businesses' contributions to sustainability (source: own creation).

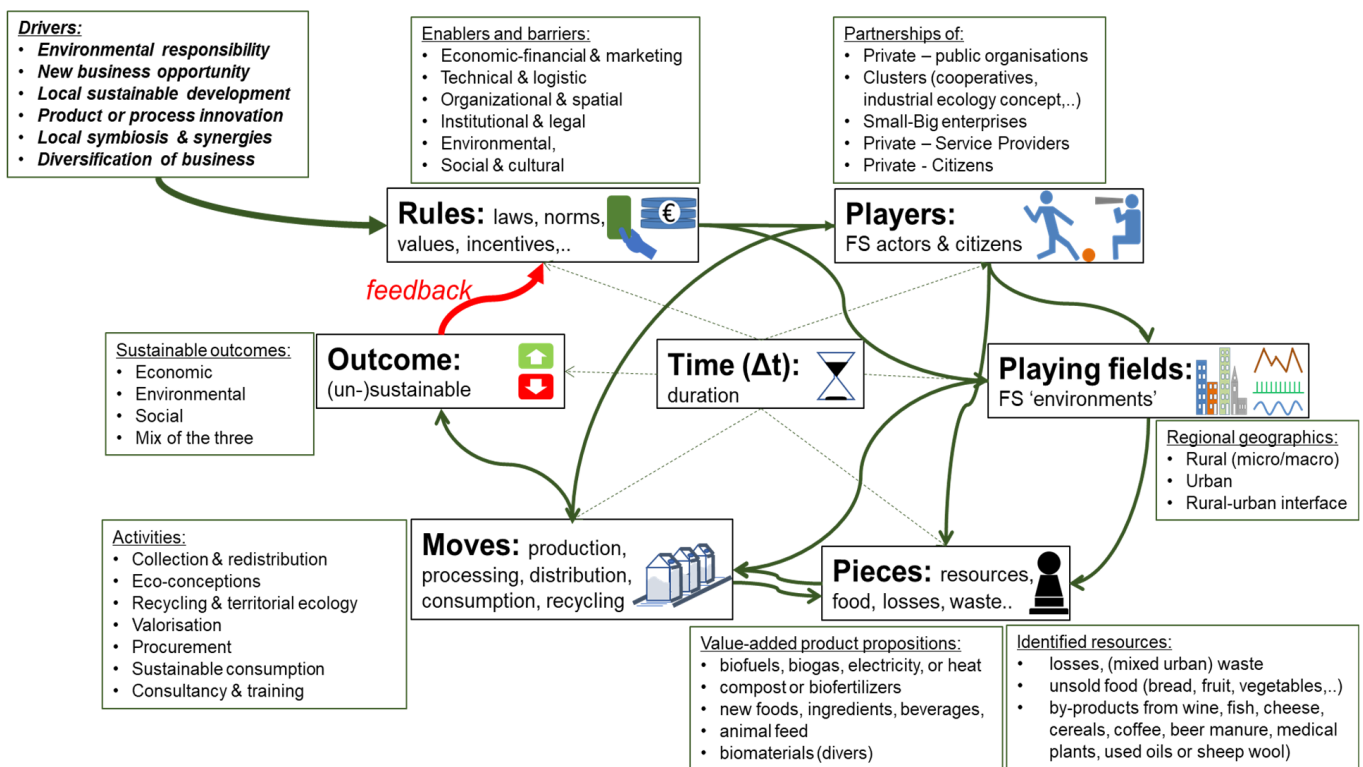
Sustainability Dimension	Example	Case
Economic	higher added-value creation	10
	extra revenues	18
	territorial business development	31
Environmental	reduction in glass waste by 1400 tons/year and of CO <sub>2</sub> emissions by 390 tons/year	9
	reduction in 2600 tons of CO <sub>2</sub> /year; reduction in energy costs	14
	approximately 7180 kg unsold fruits valorized into 950 soups et 2650 jams within 9 months	11
	in total, 90% of biomass goes back to the soil, 400 tons of bio-waste valorized per year	22
Social	creation of 20 new jobs created	5
	protection of gastronomic heritage and promotion of a key local product	43
	contribution to food aid	44
Multiple	ecological production of 6000 t/year of tomatoes without fossil energies and pesticides, 150 jobs created	6
	economic and environmental (by valorizing lost food), social by redistributing surplus or unsold food products to citizens in disadvantaged situations	15
	locally valorized biomass, energy autonomy, supported existent agri-food chains, innovative governance model	28

#### 4. Discussion

Here, results are discussed concerning the use of the game concept (Section 4.1), the way circular bioeconomy business models and their systems are impacted by drivers (Section 4.2), the role of enablers and barriers (Section 4.3), and the emergence of new local and small-scale circular bioeconomy business models in the agrifood sector in France (Section 4.4).

##### 4.1. The Game Concept

In Section 3, results have been structured using the concept of a game, with its seven building blocks. This is summarized and presented in Figure 4. In this figure, the enablers and barriers provide the rules determining which steps a new business model can take in a circular bioeconomy system. The various partnership configurations symbolize the kind of players that are active in these bioeconomy systems. They are embedded by the characteristics of their playing fields, which serve as the cradle for resource provision (i.e., the pieces); in this paper, the focus is on agrifood waste and by-products. Thanks to organizational and technological innovations in resource handling (i.e., the moves), novel value propositions are provided in terms of new food and other bio-based products. These moves are contributing to either sustainable or unsustainable outcomes of bioeconomy systems. If outcomes are unsustainable, the question is raised regarding which adaptations are necessary for the system that guarantee sustainable outcomes in the future. It is the series of adaptations—i.e., the feedback and feedforwards in time—that reveal the dynamics of business models within complex and evolving bioeconomy systems.



**Figure 4.** Results presented for the seven building blocks of a game (source: own design).

#### 4.2. Circular Bioeconomy Business Models Impacted by Drivers

The emergence and dynamics of circular bioeconomy business models and systems are strongly impacted by diverse drivers. These could be (un-)foreseen shocks (such as climate-evoked stress conditions, pandemics, wars, abrupt increases in the prices of resources and energy) or positively intended interventions (such as the French law for food waste separation, accelerating the energy transition or agroecology, Farm2Fork objectives, etc.). In Figure 4, the drivers for business actors are presented according to the results from the here presented cases obtained from the platform for circular economy initiatives in France ([economiecirculaire.org](http://economiecirculaire.org)); due to the nature of this platform, the drivers are all positively oriented. It becomes apparent that these drivers enter the game concept at the level of rules (such as setting new ambitions for environmental responsibility or striving for local territorial development); however, they are impacting all other building blocks consecutively.

First, they reveal which enablers and barriers are hindering or accelerating factors. Then, they challenge the configurations of players, including various partnership models, which are seeking viable business cases, robustness and resilience while confronted with enablers and barriers. Since one is dealing with agrifood waste and the by-products of, in general, local resources, the business cases are directly related to their immediate playing field. This has direct consequences for which resources (the pieces) are becoming available and can be handled with new technologies and/or logistic schemes (the moves). It is at this step that new value product propositions arise, which feeds back to the pieces to be considered in circular bioeconomy approaches. Their functionalities and specificities define the outcomes. If they contribute to local sustainable development or eco-socio-friendly products that create economic value for a diversity of players, then the outcomes are contributing to the transition towards sustainable food and bioeconomy systems. In our set of case studies, the sustainable outcomes mentioned by the enterprises were again all positive. Nevertheless, if there are unforeseen trade-offs or any other negative consequences, the outcomes could be unsustainable.

This implies that new insights are fed back to further improve and optimize all the building block operations once more. In this sense, the game concept is also circular in its usage when striving for better outcomes.

#### 4.3. Enablers and Barriers

In general, the results regarding the enablers and barriers confirm those from earlier studies with international business model case studies [33–35]; however, environmental, social and cultural factors seem to be particularly more prominent in France. Here, socio-cultural trends, local community support and (short) communication channels are dominating factors in the success of cases. Economic–financial and marketing factors are somewhat less emphasized in France. This may be due to public subsidies for the circular economy initiatives and/or to the still rather resource instead of market orientation of the cases.

Other kinds of enablers or barriers were not mentioned in the studied cases, that were considered important for the success of circular bioeconomy business models [33]. Among the technological and logistic aspects, hygiene and safety, in particular, could be detrimental factors. This is due to accumulation effects and, consequently risks passing thresholds in circular approaches. Next, market access for products developed in remote areas could be a problem if they are not directly consumed in situ. Under the socio-cultural conditions, safeguarding and the strengthening of cultural and gastronomic heritage could be a strong enabling factor, as well as social aid such as via food banks.

#### 4.4. The Emergence of New Local Small-Scale Circular Bioeconomy Business Models

Finally, it was found that different types of new circular bioeconomy business models have emerged in France in the past decade, in line with national and regional public policies and agendas. The cases analyzed are overwhelmingly (very) small-scale and multi-actor collaborative business models. They are acting at a local level, with a high number of industrial and territorial ecology projects. These new business models differ from the large international bioeconomy enterprises in their way of resource handling: they are less research-oriented and use less highly specialized biotechnologies. Their types of partnerships often include other nearby small actors, such as bakeries, breweries, gardeners, etc., instead of research institutes or consulting agencies. Their type of value propositions are often still rather low value-added propositions, such as biogas, fertilizers or compost.

Such a co-existence of different business models seems to be important for further advancing the circular bioeconomy in the country, based on different entrepreneurial strategies, and for exploiting biomass resources in different ways. Although they are not always economically viable and often depend on public financial support, these territorial small initiatives may contribute to local sustainable development in the long term. This can be achieved by stimulating business development and employment, offering environmentally friendly products while saving resources, and providing new food (ingredients) and new jobs. In addition, it may result in the increased resilience of rural and urban territories and their actors, especially in times of crisis [54]. Finally, they may trigger others to jointly and efficiently tackle the future (bio-)resources gap by continuously providing food, energy and other bio-based materials, even though today they are not yet sufficient in number, geographical spread and in their efficient resource handling. However, to overcome their dependence on public subsidies, their business strategies should become more market or user oriented; here, public or private customers who could pay for and add value to their products locally should be identified and targeted. This is already the case in France for the public procurement of local (organic) quality food products, increasingly consumed, for example, in school canteens [55].

## 5. Conclusions

Up to date, research on circular bioeconomy business models in France has mainly focused on large international bioeconomy or biotechnology clusters [36–38], while local

small-scale initiatives have rather been overlooked. Therefore, 44 different territorial, small and collaborative circular bioeconomy business models from the agrifood sector have here been reviewed concerning their drivers, their business model elements, enablers and barriers, and contribution to sustainable development.

This study has offered the first insights into new circular bioeconomy business models in France, mostly valorizing agrifood waste and by-products, and has led to a better understanding of the emergence of these business models regarding their drivers, activities and outcomes. The strategies followed by the enterprises are based on the seven circular economy pillars by ADEME, mostly recycling, sustainable procurement and industrial and territorial ecology. The geographical embeddedness and relational proximity of actors, including local cooperation and resource handling, are crucial for the success of these business models, as well as general pro-environmental consumer trends and local public support. The outcomes are positively related to the three sustainability dimensions—economic, environmental, and social. The outcomes further suggest that, in particular, small and collaborative circular bioeconomy business models could trigger resilient territorial development and counteract the future (bio-)resources gap. Then, related supporting policy measures will urgently be needed.

Next, the application of the game concept and its seven building blocks has allowed this study to demonstrate the essential elements of business models within bioeconomy systems, and the interrelations between these elements. This concept is hereby not considered as static, but dynamic and circular, providing feedback loops striving for sustainable outcomes. It would be interesting and recommendable to further explore the use of this game concept in other close-to-reality business contexts, for example, via joint systemic co-creation approaches in food or bioeconomy living labs.

As this study was based on an online review of initiatives and focused on France, further research including more in-depth case studies with interviews and field visits is recommended. This would allow a better understanding of, in particular, the value delivery and value capture elements of individual business models. Next, a cross-country comparative analysis is interesting to address the coexistence of different types of circular bioeconomy business models. Finally, more quantitative research approaches are needed to follow the dynamics of circular bioeconomy business models via a well-defined set of sustainability indicators.

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**Conflicts of Interest:** The authors declare no conflict of interest.

## Appendix A

**Table A1.** List of circular bioeconomy business models analyzed.

No	Type and Size of Initiative	Driver and Starting Date (Time)	Region (Playing Field)	Type of Resource (Pieces)	Key Partners/Clients (Players)	Activities and Value Propositions (Moves)	CE Principles Applied (Moves)	Enablers and Barriers (Rules)	Sustainability Benefits (Outcomes)	Source
1	Farm, micro	sensible to environmental questions, since 2019	Occitanie	organic waste, manure	nearby village, super-markets	worm farm; organic vermicompost	responsible consumption, recycling, sustainable procurement		valorizes more than 200 kg local waste per week	<a href="http://www.compost-vers.fr">www.compost-vers.fr</a> (accessed on 10 February 2023)
2	Beer brewery, micro	'Bread is no waste', since 2015	Auvergne-Rhône-Alpes	old unsold bread	bakery	beer based on old bread	product lifespan extension	(-) fluctuation in quantities; logistics needed for collection	valorizes 35 kg hard bread into 1300 L beer	<a href="https://www.brasserieidelaloire.fr/">https://www.brasserieidelaloire.fr/</a> (accessed on 10 February 2023)
3	Enterprise, small	since 2012	Auvergne-Rhône-Alpes	coffee grounds from distributors	large service company for waste collection and valorization	recycling of coffee grounds, valorization into logs for heating	recycling		valorizes 16 tons of coffee grounds per year	<a href="http://www.arabica-e-chocolat.com/engagements/">www.arabica-e-chocolat.com/engagements/</a> (accessed on 10 February 2023)
4	Distillery, small	diversification needed, since 2014	Occitanie	wine waste and by-products	research, public partners (ADEME, region)	portfolio of various new products for international sales	functional economy, industrial and territorial ecology, sustainable procurement	(-) need for new skills (language), technologies fiscal constraints	create new biorefinery model optimizing all resources	<a href="https://www.economiecirculaire.org/initiative/h/bioraffinerie-vers-un-modele-d-economie-circulaire.html">https://www.economiecirculaire.org/initiative/h/bioraffinerie-vers-un-modele-d-economie-circulaire.html</a> (accessed on 10 February 2023)

Table A1. Cont.

No	Type and Size of Initiative	Driver and Starting Date (Time)	Region (Playing Field)	Type of Resource (Pieces)	Key Partners/Clients (Players)	Activities and Value Propositions (Moves)	CE Principles Applied (Moves)	Enablers and Barriers (Rules)	Sustainability Benefits (Outcomes)	Source
5	Power company, small	since 2014	Provence Alpes-Côte d'Azur	biomass	local industries, municipalities	local biomass conversion into electricity and heat	industrial and territorial ecology		economic and ecological value via new biomass conversion technology, 20 new jobs	<a href="https://www.minigreenpower.com/">https://www.minigreenpower.com/</a> (accessed on 10 February 2023)
6	Cooperative medium-sized	the proximity of actors has enabled the symbiosis project, since 2007	Nouvelle Aquitaine	tomatoes	large oil company	water heat from oil production used to heat greenhouses	industrial and territorial ecology, sustainable procurement	(+) proximity and long-term partnership (25 years); (-) regulatory, administrative barriers	ecological production of 6000 t/year of tomatoes (without fossil energies and pesticides), 150 jobs created	<a href="http://tomdaqui.com/">http://tomdaqui.com/</a> (accessed on 10 February 2023)
7	Company, medium-sized	importance of not throwing used oils away, since 2016	Auvergne-Rhône-Alpes	oil	partnership with a waste collecting company and strategic consultancy	collect used oils and convert them into biofuels	responsible consumption, recycling, sustainable procurement, eco-conception	(+) media communication, users	awareness creation for environmental problem; 100% of the collected oil is revalorized	<a href="https://www.labaraqueahuile.fr/">https://www.labaraqueahuile.fr/</a> (accessed on 10 February 2023)
8	Association, micro	offer local solution for organic waste collection and treatment, since 2015	Auvergne-Rhône-Alpes	organic waste	waste depositories, public partners	consulting, organic waste collection and treatment (composting)	recycling, sustainable procurement	(+) proximity for waste collection and partners; (-) financing	treatment of 2 K tons of biowaste per year,	<a href="http://compostond.fr/">http://compostond.fr/</a> (accessed on 10 February 2023)



Table A1. Cont.

No	Type and Size of Initiative	Driver and Starting Date (Time)	Region (Playing Field)	Type of Resource (Pieces)	Key Partners/Clients (Players)	Activities and Value Propositions (Moves)	CE Principles Applied (Moves)	Enablers and Barriers (Rules)	Sustainability Benefits (Outcomes)	Source
9	Association, micro	bring chain actors together to enhance reuse of bottles, since 2018	Occitanie	beverage chain (beer, wine, fruit bottles)	multiple from the beverage chain and public	collect, clean and reuse returnable drink bottles	product lifespan extension, responsible consumption, functional economy, sustainable procurement		reduction in glass waste by 1400 tons/year and of CO <sub>2</sub> emissions by 390 tons/year	<a href="https://www.consignup.org">https://www.consignup.org</a>
10	Bakery, micro	cereals normally used for animal feed, but not for human food, 2018	Nouvelle Aquitaine	cereal grains from beer brewing	beer brewer	cookies based on cereal grains from brewery	responsible consumption, recycling, industrial and territorial economy	(+) proximity, openness and engagement of actors; (-) time needed	higher added-value creation	<a href="https://www.economiecirculaire.org/articles/h/patisserie-anti-gaspillage-solidaire.html">https://www.economiecirculaire.org/articles/h/patisserie-anti-gaspillage-solidaire.html</a> (accessed on 10 February 2023)
11	Enterprise, micro	since 2018	Nouvelle Aquitaine	unsold fruit and vegetables	super-markets	collect and convert unsold fruit and vegetables into soups, juices and jams	responsible consumption, recycling, eco-conception	support of local communities, knowledge of retailers; (-) time needed	valorizes 7180 kgs within 9 months, 950 soups et 2650 jams	<a href="https://www.recita.org/initiative/h/cyfruileg-les-fruits-et-legumes-invendus-en-jus-soupes-et-confitures.html">https://www.recita.org/initiative/h/cyfruileg-les-fruits-et-legumes-invendus-en-jus-soupes-et-confitures.html</a> (accessed on 10 February 2023)

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12	Shops, small	since 2013	Île-de-France	various agri-food products	consumers	in bulk sales of food products	responsible consumption		consumers can reduce environmental impact by buying without packaging	<a href="http://daybyday-shop.com/">http://daybyday-shop.com/</a> (accessed on 10 February 2023)
13	Enterprise, small	since 2015	Auvergne-Rhône-Alpes	various co-products from food industry (breweries, bakeries, milk etc.)		valorization of co-products for animal feed	sustainable procurement		production of 60,000 tons of flour for animal feed per year	<a href="http://www.flash-infos.com/actu/information-economique-rhone-alpes/alimentation-animale-bondasimplante-a-pont-de-vaux/">http://www.flash-infos.com/actu/information-economique-rhone-alpes/alimentation-animale-bondasimplante-a-pont-de-vaux/</a> (accessed on 10 February 2023)
14	Cooperative large	since 2013	Auvergne-Rhône-Alpes	corn raid	public partners	corn raid used converted into energy via biomass heater	sustainable procurement		reduction of 2600 tons of CO <sub>2</sub> /year; reduction in energy costs	<a href="http://www.limagrain.com">www.limagrain.com</a> (accessed on 10 February 2023)
15	Company, small	against food waste, since 2012	Île-de-France	various unsold food products	retailers, distributors, communities hospitals	redistribution of surplus or unsold products to disadvantaged citizens via associations	responsible consumption, recycling, sustainable procurement		economic and environmental (lost food), social	<a href="http://www.eqosphere.com">http://www.eqosphere.com</a> (accessed on 10 February 2023)

Table A1. Cont.

No	Type and Size of Initiative	Driver and Starting Date (Time)	Region (Playing Field)	Type of Resource (Pieces)	Key Partners/Clients (Players)	Activities and Value Propositions (Moves)	CE Principles Applied (Moves)	Enablers and Barriers (Rules)	Sustainability Benefits (Outcomes)	Source
16	Company, medium-sized	since 2017	Auvergne-Rhône-Alpes	byproducts from red fruits	industrial partner	red fruit by-products valorized into high added value ingredients for animal feed	industrial and territorial ecology	geographical proximity of partners (confidence); (-) some products do not fulfil quality requirements	valorizes 150 tons per year	<a href="https://ravifruit.com/fr">https://ravifruit.com/fr</a> (accessed on 10 February 2023)
17	Association, micro	since 2019	Nouvelle Aquitaine	food waste	restaurant owners, gardeners	collection of food waste with bicycles, valorization into compost	responsible consumption, recycling, sustainable procurement		local environmental initiative	<a href="https://lescarriolesvertes.org/">https://lescarriolesvertes.org/</a> (accessed on 10 February 2023)
18	Enterprise, medium-sized	find solution for coproducts from fish processing, since 2016	Occitanie	fish co-products (tuna)	leather industry	valorization of fish coproducts into leather (e.g., for shoes)	recycling, sustainable procurement	(+) participation in trade fairs for promotion; (-) time for R&D	extra revenues, waste avoidance	<a href="https://www.groupebarba.com/fr/accueil/">https://www.groupebarba.com/fr/accueil/</a> (accessed on 10 February 2023)
19	Restaurant, micro	avoid food waste, since 2018	Île-de-France	various food products, fruits and vegetables	retailers	propose dishes with 80% of products otherwise thrown away (expiration date)	recycling	(+) loyalty of consumers; (-) decrease in collected food	reduction in food waste by 400 kg per week, 2–3 jobs created	<a href="https://www.lebocalpierrefitte.fr/">https://www.lebocalpierrefitte.fr/</a> (accessed on 10 February 2023)

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No	Type and Size of Initiative	Driver and Starting Date (Time)	Region (Playing Field)	Type of Resource (Pieces)	Key Partners/Clients (Players)	Activities and Value Propositions (Moves)	CE Principles Applied (Moves)	Enablers and Barriers (Rules)	Sustainability Benefits (Outcomes)	Source
20	Association, micro	develop and promote biobased construction, since 2015	Auvergne-Rhône-Alpes	different chains: wood, hemp, sheep's wool	farmers, house builders, regional trade chamber	valorization of bioresources for insulation in the construction sector	sustainable procurement		provides eco-friendly materials	<a href="https://www.eclaira.org/initiative/h/le-developpement-de-la-construction-biosourcee-en-auvergne.html">https://www.eclaira.org/initiative/h/le-developpement-de-la-construction-biosourcee-en-auvergne.html</a> (accessed on 10 February 2023)
21	EU project with Association, small	treatment of sludge and wastewater from fish farming, 2016–2020	Occitanie	fish farming	20 European research partners	valorization of fish farming waste (sludge) with worms into compost	industrial and territorial ecology, recycling, eco-conception	(+) increasing awareness of the problem, collective management of waste, financial support	conversion of 40% of sludge into worm compost (worms are ideal to digest organic matter)	<a href="http://lombritek.com/lk/">http://lombritek.com/lk/</a> (accessed on 10 February 2023)
22	Industrial ecology park, small	sustainable economic development, since 2007	Auvergne-Rhône-Alpes	agricultural by-products	various enterprises, research institutes and public partners	biomass conversion into biochar, biogas food additives; joint R&D, training	industrial and territorial ecology		in total, 90% of biomass goes back to the soil, 400 tons of biowaste valorized/year	<a href="http://www.parc-naturopole.fr/">http://www.parc-naturopole.fr/</a> (accessed on 10 February 2023)
23	Enterprise, medium-sized	fight against food waste, create jobs for sustainability and quality goals, 2016	Auvergne-Rhône-Alpes	urban biowaste	diverse private and public partners	innovative solution for valorizing locally urban biowaste into compost	industrial and territorial ecology, recycling	(+) public laws for energy transition and waste separation	contribute to local circular economy, 150 tons of biowaste collected and valorized/year	<a href="https://alchimistes.co/">https://alchimistes.co/</a> (accessed on 10 February 2023)

Table A1. Cont.

No	Type and Size of Initiative	Driver and Starting Date (Time)	Region (Playing Field)	Type of Resource (Pieces)	Key Partners/Clients (Players)	Activities and Value Propositions (Moves)	CE Principles Applied (Moves)	Enablers and Barriers (Rules)	Sustainability Benefits (Outcomes)	Source
24	Start-up enterprise, micro	desire to develop an ecological and responsible project, since 2018	Occitanie	sheep wool	public partners and support	valorize sheep wool for insulated/cool bags	product lifespan extension, responsible consumption, recycling, sustainable procurement, eco-conception	complementary skills, made in France, (-) need to know support options, limited production capacity, recruitment in rural area	local valorization of eco-resources instead of plastic bags	<a href="https://lemoutongivre.com/">https://lemoutongivre.com/</a> (accessed on 10 February 2023)
25	Start-up, micro	fight against food waste, since 2021	Nouvelle Aquitaine	unsold bread	bakeries, restaurants, super-markets etc.	revalorize unsold bread into new flour via new technology; promotional activities	product lifespan extension, responsible consumption, recycling, sustainable procurement, eco-conception	(-) not everybody is sensitive for the waste topic	eco-responsible waste treatment service, 150 professionals equipped with the new technology in 3 years	<a href="http://www.explicat.fr/crumblor/">http://www.explicat.fr/crumblor/</a> (accessed on 10 February 2023)
26	Enterprise, medium-sized	fight against food waste, since 2005	Île-de-France	biowaste and used oils from cooking	professionals from the agrifood chain and restaurants	collection and valorization of biowaste into pet food, bioenergy and fertilizers	recycling		creation of 200 jobs in France and 1600 in the world	<a href="https://refood.fr/">https://refood.fr/</a> (accessed on 10 February 2023)

Table A1. Cont.

No	Type and Size of Initiative	Driver and Starting Date (Time)	Region (Playing Field)	Type of Resource (Pieces)	Key Partners/Clients (Players)	Activities and Value Propositions (Moves)	CE Principles Applied (Moves)	Enablers and Barriers (Rules)	Sustainability Benefits (Outcomes)	Source
27	Industrial ecology park, micro	rethink the way of functioning of industrial parks, territorial development, since 2011	Nouvelle Aquitaine	mussel shells, coffee ground, wood fiber,	local enterprises, research	green roofs made from agrifood by-products	industrial and territorial ecology, recycling, eco-conception	(+) scientific and private company support, public financing	100% local bioresources, reduction in environmental impact	<a href="http://reseau-biotop.com/1/">http://reseau-biotop.com/1/</a> (accessed on 10 February 2023)
28	Public-private partnership project, small	eco-development project, since 2017	Auvergne-Rhône-Alpes	livestock effluents	Biogas company	livestock effluents converted into biogas via anaerobic digesters	industrial and territorial ecology, sustainable procurement	(+) territorial embeddedness, ppp, (-) financing, acceptability	locally valorize biomass, energy autonomy, support existent food chains, innovative governance model	<a href="https://www.pays-salers.fr/">https://www.pays-salers.fr/</a> (accessed on 10 February 2023)
29	Enterprise, medium-sized	initiator was a restaurant owner, since 2013	Île-de-France	urban food waste	restaurants	service (support and training); collection and valorization of food waste; compost, biogas	sustainable consumption, recycling	complementary skills, knowledge of clients' needs, public regulation, (-) financing	establishment of 500 collection points, waste from 150,000 meals per day	<a href="https://www.moulinot.fr/">https://www.moulinot.fr/</a> (accessed on 10 February 2023)

Table A1. Cont.

No	Type and Size of Initiative	Driver and Starting Date (Time)	Region (Playing Field)	Type of Resource (Pieces)	Key Partners/Clients (Players)	Activities and Value Propositions (Moves)	CE Principles Applied (Moves)	Enablers and Barriers (Rules)	Sustainability Benefits (Outcomes)	Source
30	Community-oriented enterprise, micro	100% valorization of organic resources, since 2014	Occitanie	organic waste	multi-actor	waste collection and valorization into biogas and fertilizers	industrial and territorial ecology, recycling, sustainable procurement	land-use control, collaboration, financing capacity	industrial ecology with synergies	<a href="https://www.cler-verts.fr/">https://www.cler-verts.fr/</a> (accessed on 10 February 2023)
31	Start-up enterprise, micro	create new portfolio of eco-responsible leather, since 2021	Nouvelle Aquitaine	fish skins	fisheries, leather industry	valorize fish skins (tannin extracts) into eco-leather (shoes, gloves, furniture . . . )	industrial and territorial ecology, eco-conception, sustainable procurement	availability and quality of by-products, curiosity of the public towards products, (-) marketing and financing	adding value to fish by-products, territorial business development	<a href="http://www.femer.fr/">http://www.femer.fr/</a> (accessed on 10 February 2023)
32	Private-private partnership project, medium-sized	industrial fish waste considered without value, since 2017	Occitanie	byproducts from the sea	large waste collection company	fish waste and by-products valorized into biofertilizers	industrial and territorial ecology, recycling	well-established logistics, central positioning of the firm	valorizes 500 tons of by-products per year	<a href="https://www.veolia.fr/medias/actualites/veolia-stef-sassocient-valoriser-coproduits-mer">https://www.veolia.fr/medias/actualites/veolia-stef-sassocient-valoriser-coproduits-mer</a> (accessed on 10 February 2023)
33	Association, micro	create new local and circular food waste valorization chain, since 2019	Auvergne-Rhône-Alpes	local food waste	individual households	bicycle collection and valorization of food waste into biofertilizers	recycling	public support and training, (-) difficult to get access to land for composter, transition from free-of-charge to payable service	development of a local circular economy	<a href="https://rovalterre.org/">https://rovalterre.org/</a> (accessed on 10 February 2023)

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34	Enterprise, micro	important losses (about 30%) in the fruit and vegetable sector, since 2013	Occitanie	fruit and vegetable losses from organic production	multi-actor	valorization of ugly or overripe fruits and vegetables into juices, compotes, soups	sustainable procurement, sustainable consumption	direct local juice production by producers without intermediary, (-) farmers without marketing skills	valorizes 1000 tons per year; 5 jobs created	<a href="https://si-bio.fr/fr">https://si-bio.fr/fr</a> (accessed on 10 February 2023)
35	Start-up enterprise, micro	desire to do something for the environment, since 2020	Île-de-France	brewers' grains	breweries, bakeries	valorization of brewers' grains into edible tableware	sustainable consumption, sustainable procurement, eco-conception	laws pushing professionals to change, (-) the COVID-19 pandemic	replaces throw-away tableware	<a href="http://somalte.com/">http://somalte.com/</a> (accessed on 10 February 2023)
36	Enterprise, small	since 2017	Auvergne-Rhône-Alpes	whey/lactoserum	multi-actor: enterprise consists of farmers and milk producers	valorization of whey into heat, electricity and fertilizers via anaerobic digestion	industrial and territorial ecology	geographical proximity, quality, network	heat for own use (greenhouse and fodder drying), reduction in transportation, CO <sub>2</sub> reduction	<a href="https://www.eclaira.org/initiative/h/synergie-industrielle-fromagerie-de-la-drome-agritexia-valorisation-du-petit-lait-de-fromagerie-en-energie.html">https://www.eclaira.org/initiative/h/synergie-industrielle-fromagerie-de-la-drome-agritexia-valorisation-du-petit-lait-de-fromagerie-en-energie.html</a> (accessed on 10 February 2023)



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37	Biogas unit, micro	importance of local circular economy, since 2015	Auvergne-Rhône-Alpes	livestock manure, agrifood waste	multi-actor	valorization of livestock manure and local agrifood waste into electricity, heat	recycling		valorizes 18,500 tons of agricultural and 17,500 tons of food waste per year	<a href="https://www.methelec.com/">https://www.methelec.com/</a> (accessed on 10 February 2023)
38	Enterprise, micro	environmental challenge to collect and valorize the high volumes of this by-product, since 2016	Auvergne-Rhône-Alpes	whey/lactoserum (liquid co-product from milk production)	multi-actor between inter-professional and milk producers	collection and valorization of whey into milk powder and creme for the food industry	industrial and territorial ecology	common interest given by AOP zone, activity for 5 years stabilizing, (-) investment costs, market price dependence	avoid environmental problem via spreading, can be used for agro-industrial use	<a href="https://www.eclaira.org/initiative/h/une-initiative-collective-de-gestion-du-lactoserum-en-production-fermiere.html">https://www.eclaira.org/initiative/h/une-initiative-collective-de-gestion-du-lactoserum-en-production-fermiere.html</a> (accessed on 10 February 2023)
39	Enterprise, small	aim to valorize waste in situ, since 2017	Auvergne-Rhône-Alpes	urban food waste	multi-actor: cafeterias, enterprises, residents, public	collection and valorization of urban food waste into compost	functional economy, industrial and territorial ecology, recycling	(+) proximity, (-) insufficient space in city, investment costs, time needed for composting	local waste usage, creation of new jobs, CO <sub>2</sub> reduction	<a href="https://www.upcycle.org/">https://www.upcycle.org/</a> (accessed on 10 February 2023)
40	Enterprise, large multi-national	valorization of residues for quality and biodiversity protection, 2011	Occitanie	plant residues		valorization of medical plant residues into heat for own use	industrial and territorial ecology, recycling, sustainable procurement		valorizes 1000 tons of residues, reduction in CO <sub>2</sub> and in own costs for gas	<a href="https://www.pierre-fabre.com/fr/article/la-chaudiere-biomasse-de-lusinetarnaise-pierre-fabre-dermo-cosmetique-primee">https://www.pierre-fabre.com/fr/article/la-chaudiere-biomasse-de-lusinetarnaise-pierre-fabre-dermo-cosmetique-primee</a> (accessed on 10 February 2023)

Table A1. Cont.

No	Type and Size of Initiative	Driver and Starting Date (Time)	Region (Playing Field)	Type of Resource (Pieces)	Key Partners/Clients (Players)	Activities and Value Propositions (Moves)	CE Principles Applied (Moves)	Enablers and Barriers (Rules)	Sustainability Benefits (Outcomes)	Source
41	Association, micro	landfill of biowaste not acceptable any more, need for quality organic fertilizers, 2019	Normandie	biowaste from agriculture	farmers, farmers associations, technical support centers, public	training, support for professionals, sensitization of citizens, biowaste valorization into compost	recycling		create local jobs	<a href="https://neci.normandie.fr/initiatives/valorisation-des-biodechets-des-professionnels">https://neci.normandie.fr/initiatives/valorisation-des-biodechets-des-professionnels</a> (accessed on 10 February 2023)
42	Enterprise, small	pioneer in the domain, since 2016	Nouvelle Aquitaine	agrifood losses, waste and industrial food by-products	industrial and research	valorization of biowaste via insects into animal feed (proteins, oils), biofuels and fertilizers	industrial and territorial ecology, recycling, eco-conception, sustainable procurement	trend for waste valorization and agro-ecology, (-) regulation is a limiting factor, financing, process upscaling	offer new waste-based products, 13,000 tons of waste valorized per year	<a href="https://www.compagniedesinsectes.com/">https://www.compagniedesinsectes.com/</a> (accessed on 10 February 2023)
43	Association, micro	incentive for individuals to replant traditional apple trees, since 2019	Normandie	apple waste and by-products	tourism office for sales, local bakeries, public	valorization of apple waste and by-products into dried flour as alternative for gluten-allergic consumers	industrial and territorial ecology		gastronomic heritage and promotion of a key local product, waste valorization, job creation	<a href="https://actu.fr/normandie/epaignes_27218/lassociation-3-pommes-depaignes-se-lance-dans-fabrication-farine_24043864.html">https://actu.fr/normandie/epaignes_27218/lassociation-3-pommes-depaignes-se-lance-dans-fabrication-farine_24043864.html</a> (accessed on 10 February 2023)

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44	Social enterprise, micro	social and environmental driver, since 2018	Île-de-France	food surpluses from restaurants	restaurants	collection of food surpluses from restaurants and redistribution	industrial and territorial ecology, sustainable procurement, sustainable consumption	(-) competition of food surplus resources	waste reduction, contribution to food aid	<a href="https://www.excellents-excedents.fr/">https://www.excellents-excedents.fr/</a> (accessed on 10 February 2023)

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