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Mechthild Donner[a,*], Anne Verniquet[b], Jan Broeze[c], Katrin Kayser[d], Hugo De Vries[e]

[a] INRAE – French National Research Institute for Agriculture, Food and Environment, UMR MOISA (Univ Montpellier, CIRAD, CIHEAM-IAMM, INRAE, Institut Agro), 2 Place Pierre Viala, 34060 Montpellier, France
[b] SOFIES – Solutions for Industrial Ecosystems S.A., Quai du Seujet 28, PO BOx 209, 1211 Geneva, Switzerland
[c] Wageningen Food & Biobased Research, 6708 WG Wageningen, Netherlands
[d] IBBK – Fachgruppe Biogas GmbH, 74592 Kirchberg/Jagst, Germany
[e] INRAE – French National Research Institute for Agriculture, Food and Environment, UMR IATE (Cirad, INRAE, Institut Agro, University Montpellier), 2 Place Pierre Viala, 34060 Montpellier, France

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ABSTRACT

For a transition from a linear, 'take-make-dispose' economy to a sustainable usage of all constituents of renewable resources in cascading and circular pathways, new business models valorising streams that are currently considered as waste are needed.

The aim of this article is to understand critical success and risk factors of eco-innovative business models that contribute to a circular economy via agricultural unavoidable waste or by-products valorisation.

39 cases were studied focusing on agricultural side stream conversion into valuable products. Semi-structured interviews were performed and secondary data collected. Cases were analysed according to types of initiatives, main objectives, resources and valorisation pathways, as well as external and internal factors that have influenced the businesses over time.

Following success and risk factor categories are identified: (1) technical and logistic, (2) economic, financial and marketing, (3) organisational and spatial, (4) institutional and legal, (5) environmental, social and cultural. Herein, specific factors for the agricultural sector are 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.

Insights from this study can help farmers and agribusiness managers by defining and adapting their strategies within their local contexts. They also show that for shifting from linear agro-food chains to a circular system, individual businesses need to evolve towards more dynamic and integrated business models, in which the macro-environment sets the boundary conditions for successful operations.

1. Introduction

The concerns about the limitations of economic growth and the efficient usage of all natural resources date back more than half a century. In 1972, the Club of Rome has published a first report *Limits of Growth* (Meadows et al., 1972). Fifteen years later, the famous report of the World Commission on Environment and Development *Our Common Future* (Brundtland et al., 1987) has called for new approaches to manage environmental resources. More recently, the circular economy approach has increasingly been promoted by policymakers. In circular economy thinking, the continuous flow of technical and biological materials in the value circle is enhanced, and waste is preferentially avoided, reduced, reused and valorised, or alternatively fully recycled (EMF, 2013; Murray et al., 2017). Various actions plans have been implemented worldwide (e.g. China Circular Economy Promotion Law, 2008; EU Report on the Implementation of the Circular Economy Action Plan, 2019), supported by instruments such as taxes or financial subsidies (Ghisellini et al., 2016) and specific indicators (Moraga et al., 2019). Diverse strategies have been developed, in different parts of the value chain (Kalmykova et al., 2018). However, circular economy, as an

* Corresponding author.
E-mail address: mechthild.donner@inrae.fr (M. Donner).

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emerging concept (Velenturf et al., 2019), has rather been used as an umbrella term (Homrich et al., 2018), and is still not yet well defined (Kirchherr et al., 2017; Reike et al., 2018). Moreover, the relation between sustainability, bioeconomy and circular economy is also still underexplored (D'Amato et al., 2017; Geissdoerfer et al., 2017; Millar et al., 2019), despite recent efforts. Examples of the latter are (i) integrated biorefinery approaches (Venkata Mohan et al., 2016; Vea et al., 2018; Dahiya et al., 2018) based on the principle of cascading, i.e. a diversified use of waste streams through consecutive production processes (Ghisellini et al., 2016), (ii) food waste hierarchy approaches integrating the circular economy principles 'reuse, recycle, recover' (Papargyropoulou et al., 2014; Teigiserova et al., 2020), and (iii) approaches that analyse the links between sustainability and bioeconomy (Ronzon and Sanjuán, 2020).

For implementing the circular economy, large societal changes and reforms of the entire economic system are required, including production and consumption activities (Vermunt et al., 2019; Yuan et al., 2006). Firms are key actors within the transition by significantly changing their ways of production (Vermunt et al., 2019). Since several years, more and more research attention is paid to sustainable and/or circular business models aiming to increase economic growth while minimizing negative environmental and societal impact (Stubbs and Cocklin, 2008; Boons and Lüdeke-Freund, 2013; Schaltegger et al., 2016; Lewandowski, 2016; Antikainen and Valkokari, 2016). Those 'new business models' create a multiple and shared value, i.e. not only economic but also environmental and social value (Jonker, 2012). Circular business models deal with the question of how to create, deliver and capture value with and within closed material loops (Mentink, 2014), e.g. by slowing, closing, and narrowing resource loops (Bocken et al., 2016).

The objective of this article is to identify and understand the critical success and risk factors of eco-innovative business models that contribute to the transition towards a circular economy via agricultural waste and by-products valorisation. Knowledge and empirical data about the reasons that favour or hinder a practical implementation of a circular economy are important and have until now been 'somewhat modest' (Tura et al., 2019: 90). The agro-food sector is particularly concerned by circular economy thinking, as current food production and consumption habits are unsustainable (Jurgilevich et al., 2016; Barros et al., 2020). The European Circular Economy Action Plan has defined food waste as a priority area (EC, 2015). Food is wasted all along the food supply chain, in Europe mostly at the consumption stage (FUSIONS, 2016), but for some food groups also substantially in primary production (fruits, vegetables, sugar beet) or processing and manufacturing (fish, oil crops) stages (Caldeira et al., 2019). It is estimated that around 88 million tonnes of food (FUSIONS, 2016) and 700 million tonnes of crops (Pawelczyk, 2005) are wasted each year in Europe. Moreover, according to the FAO (2015), food production and food supply chains consume approximately 30% of the total global energy production, and with a population estimated to reach 9 billion people in 2050, the demand for agricultural resources and food products will further increase.

Research on success and risk factors for circular business models is emergent, and to our best knowledge, no article exists yet on this topic in the agricultural domain. Previous studies analysing factors that drive or inhibit sustainable or circular businesses are often very general or conceptual in nature (Tura et al., 2019), limited to insights from a single country with their specific contexts (Vermunt et al., 2019) - thus cannot automatically be applied to other countries; in addition, they focus either on companies internal (Long et al., 2018) *or* external (Laukkanen and Patala, 2014) factors.

In this article, an empirical and multiple case study of critical success and risk factors of circular business models in the agricultural sector is presented, with an analysis of 39 cases mainly from Europe but also from Asia and two from the USA. These initiatives valorise agricultural waste and by-products via circular and closed-loop approaches. In the next section, opportunities and challenges of agricultural waste and by-products conversion are highlighted and a short review of previous literature on general success factors and barriers of circular business models from other sectors than agriculture is given.

2. Background

2.1. Agricultural waste and by-products conversion: opportunities and challenges

Definitions of food losses and waste vary amongst institutions and are not always consistent (Chaboud and Daviron, 2017; Bellamare et al., 2017; Teigiserova et al., 2020). According to the FAO (2011) and the U. S. Department of Agriculture's Economic Research Service (Buzby et al., 2014), food losses and waste refer to the decrease in *edible food* mass. Agricultural waste and by-products, however, are usually defined as plant or animal residues that are not (or not further) processed into food or feed (OECD, 1997). They are the non-food product outputs of agricultural production and processing and comprise animal waste (manure, animal carcasses), food processing waste, crop waste (e.g. corn stalks, drops and culls from fruit and vegetables) and hazardous or even toxic waste (e.g. pesticides, insecticides and herbicides) (Obi et al., 2016). They often create environmental and economic burdens in the farming and primary processing sectors, which can be amplified by regional specialization of either crop or animal production (Gontard et al., 2018). For example, a high concentration of animal manure results in 'bacteria contamination, high greenhouse gas emissions and high organic matter and nutrients (e.g. nitrogen) loads' (Gontard et al., 2018: 2). However, agricultural waste and by-products can be turned into valuable resources using intensified conversion processes, resulting in new value-added products such as bioenergy, bio-fertilizers, biomaterials and biomolecules (Dahiya et al., 2018; Vea et al., 2018), depending on the biomass volume. This is illustrated in the biomass value pyramid (Fig. 1) in which the preferable higher added value trend is depicted.

The conversion of residues is crucial for supporting the decoupling of economic growth and human well-being from primary resources use, and for preventing putting pressure on land, causing adverse effects on biodiversity and jeopardizing global food security (UNEP, 2011). However, profitably exploiting waste is a highly complex and multidisciplinary problem (Tuck et al., 2012), requiring knowledge of the material, technologies, market and socio-economic issues related to the side-stream valorisation. While the challenges and opportunities for valorising agricultural waste and by-products have often been approached from a technological perspective (Golembiewski et al., 2015; Duque-Acevedo et al., 2020), e.g. via anaerobic digestion (Batstone and Virdis, 2014), biorefinery (Abecassis et al., 2014; Venkata Mohan et al., 2016) or bio-catalysis (Pellis et al., 2018), the socio-economic side has been rather neglected. Research on agricultural waste has been performed for over 60 years, mostly in the USA, India and China, but also in Latin America (Brazil and Mexico (Duque-Acevedo et al., 2020), as well as Chile, Colombia, Peru, Trinidad-Tobago and other countries), and in Europe with a specific emphasis on capturing and recycling of nutrients in the production fields themselves (EIP Agri, 2017). The number of publications has strongly increased in the past 13 years; this correlates with the introduction of the new regulatory frameworks for sustainable development and new policies and strategies for a circular economy and a bio-economy (Duque-Acevedo et al., 2020).

Spatial clustering of different businesses is considered as one adequate way for making biomass valorisations feasible (Smeets, 2011). Eco-industrial parks have gained attention with inter-company collaborations aimed at optimizing resource efficiency, more commonly called industrial symbiosis (Massard et al., 2013). Most eco-industrial parks are petrochemical, chemical, or concern diverse industries; but there are also projects and studies in different regions of the world that are orientated on a cross-chain valorisation of agricultural by-products (for

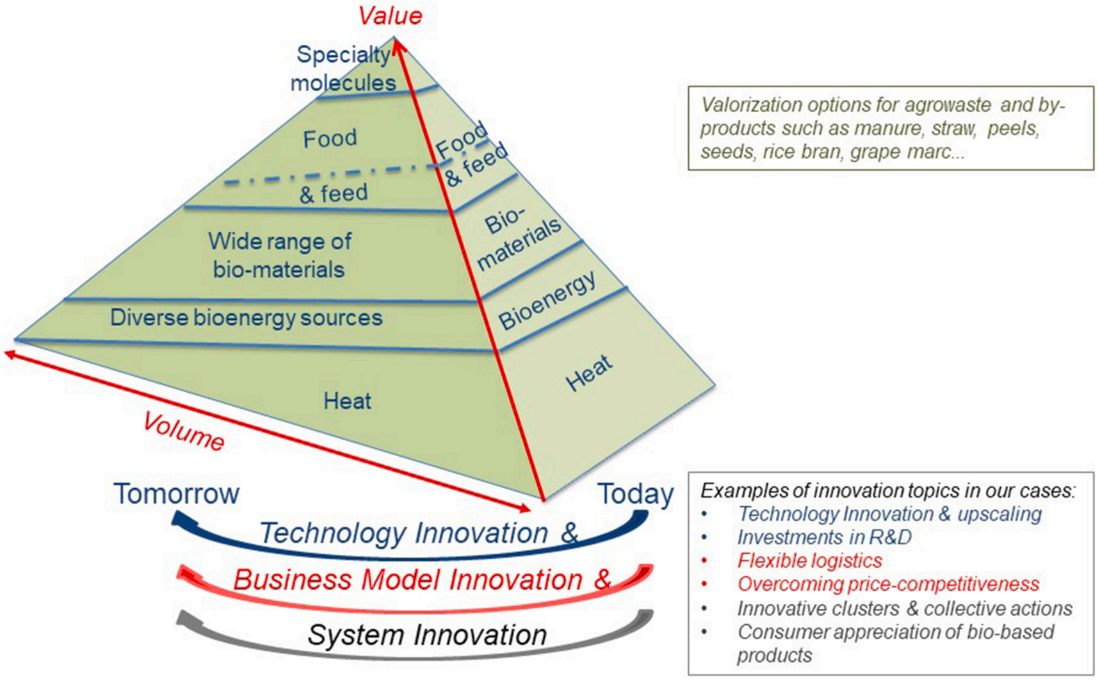

Fig. 1. Biomass value pyramid and innovation pathways resulting in higher added value products (modified from Donner et al., 2020).

agroparks or agro-industrial symbiosis e.g. Smeets, 2011; Ometto et al., 2007; Morales et al., 2019; Yu et al., 2015; for biorefineries e.g. Spaeth, 2014; Schieb et al., 2015; Cervantes et al., 2020). Efforts in R&D, business modelling and setting framework conditions are needed to permit a complete conversion of the full fresh weight of harvested crops (food plus agricultural waste) into food/feed, bio-energy and bio-based products, to increase the potential of agricultural biomass without pressure on land uses and plant productivity. Moreover, awareness must increase about the valorisation and marketing opportunities in alternative sectors, and consumers' acceptance of reused or waste-based products needs to be stimulated (Camacho-Otero et al., 2018). For an effective use of agricultural waste and by-products, innovative upgrading technologies must be linked to new business models and marketing strategies.

2.2. Circular business models: enablers and barriers

A business model is a conceptual tool to understand how a company does business (Magretta, 2002; Teece, 2010). It describes the logic of a firm, the way it operates and creates value for its stakeholders (Baden-Fuller et al., 2010; Casadesus-Masanell and Ricart, 2010). The largely recognized business model canvas by Osterwalder and Pigneur (2010) provides a simple, visual representation of the business model consisting of nine building blocks linked to the main business elements: (i) *value creation* (key activities, resources, partners), (ii) *value proposition and delivery* (products and services offered to specific customer segments via customer relations and distribution channels) and (iii) *value capture* (cost structure and revenues of a firm). This model offers a useful approach to understand and analyse details of an organization's current business model, and to support its innovation process along the value chain, towards value capturing.

A circular business model can be considered as a subcategory of business models (Antikainen and Valkokari, 2016). However, contrary to a classical business model, it does not principally aims at economic performance, but rather at the efficient use of resources, while maintaining good financial health and thus, the long-term viability of the firm (Micheaux and Aggeri, 2016). Linder and Williander (2015: 2) define a circular business model as 'a business model in which the conceptual logic for value creation is based on utilizing the economic value retained in products after use in the production of new offerings'. A common characteristic of all circular business models is the objective to reduce energy, water and material consumption and recycle or revalorise waste generated by the business. For doing so, redesign processes and new strategies are needed, which can consist of slowing, closing or narrowing resource loops (Bocken et al., 2016). Antikainen and Valkokari (2016) emphasize the collaborative character of circular business models, requiring cooperation, communication, and coordination with a wide range of actors and stakeholders. Hence, circular business models are related to sustainable business models, as they aim to create economic and environmental, and to a lesser extent social value, imply multiple stakeholders and have a long-term perspective (Ünal et al., 2019; Geissdoerfer et al., 2018).

Literature dealing with critical success or risk factors of circular business models is emergent, and as far as we know, not such a study has yet been performed for agricultural waste and by-product valorisation. Some earlier studies have presented factors that enable or hinder sustainable business model innovation in other sectors. For example, Laukkanen and Patala (2014), using institutional theory and an innovation systems approach, identified three types of external barriers for the innovation of sustainable business models: regulatory, market and financial barriers, next to behavioural and social barriers. They criticised the fact that business model innovation studies usually are focused on the firm's internal activities, although the institutional environment can have an important influence on these activities. Asswad et al. (2016) reviewed literature on sustainable business model innovation (Bocken et al., 2014; Chesbrough, 2010; Hansen et al., 2009; Lüdeke-Freund, 2010; Rennings, 2000; Schaltegger et al., 2016; Zott et al., 2011) and assigned the identified barriers – e.g. a lack of consumer acceptance of waste-based products, a missing willingness to invest in unsure and risky environmental innovations by businesses, a missing industry framework to seize and communicate sustainability to different stakeholders – to the eight archetypes of sustainable business models developed by Bocken et al. (2014). Long et al. (2018) focused on the firm's internal success factors and therefore use a change management approach. They showed that key success factors for a transition to business models for sustainability are collaboration, continuous innovation, a clear narrative and vision, profitability, a commitment to sustainability and external events such as consumers' trends or food crises. Furthermore, Rizos et al. (2016) uncovered enablers and barriers for circular SMEs, including a lack of support from the supply and demand network, insufficient capital for investment, and also sometimes a lack of government support, of technical know-how or administrative burdens. Vermunt et al. (2019) compared barriers of four different circular business models, derived from the 4R framework 'reduce, reuse, recover, recycle'. Internal barriers were a lack of knowledge and technology, organisational and financial structures, and external barriers were related to the supply chain, markets and institutions (e.g. policies, standards). Finally, Tura et al. (2019) developed a literature-based framework of drivers and barriers for circular economy businesses across various industrial sectors, proposing seven main categories: environmental, economic, social, institutional, technological-informational, supply chain, and organisational. In our article, the focus is on critical success and risk factors for circular business models that valorise agricultural waste and by-products via a cascading (i.e. diversified and consecutive valorisation paths e.g. by integrated biorefineries) or simple closed-loop (single valorisation path e.g. by biogas plants) approach.

3. Methodology

The NoAW project[1] aims at contributing to the development of innovative holistic approaches for eco-efficient conversion routes of agricultural residues and technology-orientated management strategies. One complementary work stream deals with research on the development and integration of businesses valorising agricultural waste and by-products in a circular economy context.

In this work package, multiple case studies were performed, mainly in project-partner countries from Europe and Asia, and focusing on waste and by-products valorisation in the agricultural domain (cf. Verniquet et al., 2018: NoAW Deliverable 5.1; Donner et al., 2020). The case study approach was chosen as 'an empirical enquiry that investigates a contemporary phenomenon in depth and within its real-life context' (Yin, 2009: 18). This method is particularly appropriate for developing new theories and answering questions of why and how, while it allows a better understanding of the nature and complexity of a phenomenon (Voss et al., 2002). Multiple case studies increase external validity (Voss et al., 2002). In our study, selected cases implied one or several actors more or less geographically close and involved in agricultural waste and by-products valorisation; this valorisation relied either on a simple closing loop approach or a cascade of valorisation paths implying many actors. From a technological point of view, special attention is given to initiatives implying by-products valorisation via an anaerobic digestion process.

For each case, one semi-structured interview with a key informant (a firm owner, CEO, business or R&D manager, expert from the NoAW project locally involved in the case) was performed by members of the work package team. There were four exceptions, namely two cases from the USA (cases 3 and 15, not being a geographical focus of the NoAW project) and two cases from Europe covering a wide range of circular economy orientated projects (cases 5 and 34); these cases were consulted via public data sources and served as reference. The interviews were done face-to-face, often succeeded by field visits, or alternatively by telephone, mostly in English or in some countries (Germany, France, the Netherlands) also in the mother tongue and then translated into English. As an analytical framework, the Business Model Canvas by Osterwalder and Pigneur (2010) was used, recognized worldwide as a tool to analyse business models in a synthetic and holistic way. It was completed by elements of the sustainable circular business model framework of Antikainen and Valkokari (2016), integrating the wider business eco-system, stakeholder expectations and sustainability dimensions. The interview guide included internal business aspects such as historical (origin, triggers and development of the initiative), technological (type and maturity of technologies used, examples of waste and/or by-products valorisation and outputs), organizational (governance, coordination, cooperation, logistics), financial (investments, cost-benefit structure), as well as environmental and social characteristics, but also external political-legal (policies, laws, regulations) and economic (markets, subsidies) conditions. Moreover, secondary data was collected, e.g. case-related academic and online articles (e.g. Stadler and Chauvet, 2018; Smeets, 2011; Horlings and Hinssen, 2014), websites as well as public and internal documents received from the companies. Interview and secondary data were treated via content analysis (Berg, 2009). A coding was done for each case to explore the main themes (within-case analysis), and a one-page user-friendly factsheet was elaborated for each case. Data of all cases was analysed regarding the types of initiatives, main objectives, resources and valorisation pathways, as well as external and internal factors that have influenced the development of such businesses over time.

In total, 39 cases of agricultural waste and by-products valorisation were studied in 2016–2019 (cf. annex), and that in 15 different countries: France (6 cases), Germany (4), the Netherlands (4), Switzerland (3), Italy (2), Denmark (2), Norway (1), Sweden (1), Poland (1), Hungary (1), Austria (1), Taiwan (8), Vietnam and Brazil (1), and 4 reference cases as mentioned above, two from Europe (2), and two from the USA (2). From these initiatives, 30 were classified as 'commercial enterprise and/or for profit', 7 were 'public-private partnerships' and 2 were 'non for profit'. 37 of the cases were 'on-going' while 2 'on-hold'. Moreover, 20 of the initiatives analysed were classified in the category 'Agro Food and other industries', 5 in 'Agro Food Only', 9 in 'centred around anaerobic digestion' and 5 in 'non-food industries'. Finally, 30 of the cases were 'non-clustered' and 9 'clustered'.

4. Results

Overall, results show that there is a large diversity and complementarity of initiatives that valorise agricultural waste and by-products.

The main objectives of the various businesses differ. While some initiatives aim at directly and locally adding value to agricultural by-products via anaerobic digestion processes, others look for more diversified bio-refinery applications for agro-food and other industries; quite some applications are still in a pilot-scale phase. A third group can be identified focusing on the development and commercialisation of innovative technologies, but not always exclusively based on agricultural by-products.

There is also a wide range of agricultural waste and by-products valorised, such as pig, horse or chicken manure, diverse fruit and vegetable residues, woodchips, olive cake, by-products from sugar beet and wheat, slaughterhouse waste. Furthermore, the valorisation processes and technologies vary, going from e.g. natural conversion via fly larvae or composting, traditional distillery, anaerobic digestion up to highly specialized and patented technological processes. In addition, businesses target diverse markets, including e.g. agriculture, chemistry, cosmetics and pharma, energy, construction, transport, textile or (packaging) material sectors.

With regard to the success and risk factors that have influenced the businesses over time, a large number of various factors exist, either internal to the business model or external to the business eco-system, which can be grouped in five categories. These are (1) technical and logistic (e.g. innovative or proven technologies, optimal in and out logistics), (2) economic, financial and marketing (e.g. economies of scale for clusters, co-investments and/or financial support, price competitiveness of bio-based products), (3) organisational and spatial (e.g. successful cooperation, geographical proximity, sufficient space for efficient infrastructure) (4) institutional and legal (e.g. public subsidies) and (5) environmental, social and cultural factors (e.g. acceptance or even involvement of local stakeholders).

[1] http://noaw2020.eu/

Table 1 shows the factors mentioned by the businesses/interviewees, according to the five categories. The specific success and risk factors of circular business models valorising agricultural waste and by-products are discussed in section 5.

5. Discussion

Our analysis of the success and risk factors leads to three questions: (i) what are the specific success and risk factors of circular business models valorising agricultural waste and by-products, (ii) which are the implications on the business model canvas concept for a circular economy in the agricultural sector, (iii) which management recommendations can be drawn from these insights?

(i) Results reveal that success and risk factors exist for businesses valorising agricultural waste that are generic and crucial for sustainable or circular business models in other sectors as well, as presented in recent literature. These factors concern high (initial) investment costs (Vermunt et al., 2019; Tura et al., 2019), technical uncertainties (Rizos et al., 2016; Vermunt et al., 2019), the importance of collaboration and networking (Long et al., 2018; Rizos et al., 2016), need for governmental support in particular in the starting phase of business development (Rizos et al., 2016; Tura et al., 2019), difficulties due to region-specific regulations and complex legal requirements (Laukkanen and Patala, 2014; Tura et al., 2019), the relevance of social awareness as well as customer and consumer responsiveness (highlighted by all authors mentioned in Section 2.2). Results also confirm earlier insights that for reducing risks, an exhaustive view on different factors is necessary for firms, and that the significance of success factors and barriers is highly context-specific (Tura et al., 2019). Switching to a sustainable and/or circular business model is in general considered as challenging, and there is no unique solution to overcome barriers (Asswad et al., 2016). Management scholars have therefore called for 'Open Business Models' (Zott and Amit, 2010) or 'Open Innovation' (Chesbrough, 2003), encouraging firms to open up its business model and to also use external resources and ideas as input for innovation (Asswad et al., 2010).

However, our results show that several factors are specific for circular business models valorising agricultural waste; we have grouped them in five categories, as previously specified. For the first category, concerning technical and logistic factors, innovative bio-based product-orientated technologies are often needed for enabling new, but sophisticated, conversion pathways – and technologies – from heterogeneous agricultural waste into high added value products such as biomaterials, feed, food ingredients, biomolecules. In addition, efficient and flexible in and out logistics and high storage capacities are required, because agricultural resources are voluminous and heterogeneous, their input quality varies, may rapidly deteriorate, and seasonality results in changing quantities and qualities over time. For the second category (economic, financial and marketing), enabling factors are economies of scale (for clusters such as biorefineries and agro-parks, but also for biogas plants), taking into account biological variation of resources, and strong innovative public-private or even triple helix partnerships fostering technological innovations, with joint investments in R&D. A high risk is the general lack of price competitiveness of new bio-based compared to fossil-based products dominating existing markets, especially due to often immature and still pilot-scale processes as well as quite complex characteristics of biomass. Another risk concerns the competition between different markets for the same agricultural by-products. Regarding the third category of factors (organisational and spatial), geographical proximity of different actors e.g. for ensuring the availability of local agro-resources, a sufficient space with efficient infrastructure and simplified logistics, often in form of eco-industrial parks, are conditions for success. Hereby, the investments, profits, risks and benefits are to be clearly defined with all stakeholders involved, both private and public. This is also needed to avoid resistance from inhabitants of nearby villages due to potential disturbing factors such as noise or odour emissions e.g. produced by biogas plants or stored

Table 1
Success and Risk factors of circular business models in the agricultural sector underlined in the case studies.

Category	Success Factors	Risk Factors
(1) technical and logistic	• Using a proven technology such as anaerobic digestion (Case 2)	• Outputs quality may vary due to process instabilities and mixing biomass streams (Case 2)
	• Breakthrough technology development allowing new processes (Cases 12, 14, 18, 19, 20, 21, 22)	• Clients do not trust easily a new kind of fuel (Case 12)
	• Processing facilities with sufficient capacity (Case 35)	• Technology has never been tested on a large scale (12)
	• Different companies in charge of the different steps in the biogas production (Case 38)	• The technological upscaling is critical (17)
	• Development of Bio-CCP (Carbon Capture Products) in the region (38)	• Working with fresh by-products requires efficient logistics (29); scaling-up might result into insufficient by-products available in nearby surroundings (26)
	• Availability of huge quantities of feedstock, high storage capacity (10, 39)	• Depending on the local context, agricultural residues or by-products are limited in volume per farm – need to collect them from many sources, possibly with varying qualities (26)
	• Vertical integration for value creation through non-food applications (10)	
	• Optimal logistic model for in and out flows (1)	
	• Use of local biomass resources based on long-term contracts for high security of supply (6, 30)	
	• Combining a variety of energy and supply tasks in a unified system concept to optimize synergies between individual elements by making efficient use of the energy flows between the individual plants (30) and users (13)	
(2) economic, financial and marketing	• Economies of scale in a cluster or an agro-industrial park (1, 10, 31)	• Dependency on large investment (1)
	• Joint investment in R&D and demonstration plants (3, 5)	• Difficult to be competitive with bio-based products in a context of 'too cheap' fossil-based products / energies (28, 32, 34)
	• Economic promotion of local areas through the creation of new industries, products and jobs (24, 25, 32)	• Relevancy of economy of scale, especially for capital-intensive processes (10)
	• A non-profit principle leading to maximum hedging for investors, creditors and clients (30)	• The biogas sector relies on subsidies to be profitable (6, 23, 28)
	• Going from the R&D innovation phase to	• Entering an existing market with a new

(continued on next page)

Table 1 (*continued*)

Table 1 (*continued*)

Category	Success Factors	Risk Factors
	markets: having a network of strategic partners ready to invest in the industrialization phase (3)	product is challenging (4)
	• Protecting innovative products via patents makes them more interesting for investors (33)	• Bio-based building blocks are much more expensive to produce compared to those that are mass-produced (4, 5)
	• Selling the energy produced by a small biogas plant to neighbouring households (23)	• There is competition between different sectors for the same agricultural by-products (4)
	• To scale-up and commercialize a new marketable technology or process: identify and join forces with an existing multi-national and eco-innovative actor in the same field (18, 19, 22, 24)	• Difficult to open a market for products from digestate as single plant operator due to economies of scale (2, 28)
	• Designing new products that are drop-in replacements enabling full utilization of existing logistic infrastructures (19)	• Getting (food) security/safety approvals is time consuming; it should be considered carefully in the project design and development (15, 16, 28)
	• Innovation capacities & product portfolio extension (26)	• Contractors may not know and therefore may not trust an innovative product (4)
	• Optimization of logistics costs (7, 26)	
	• Technology transfer: robust and low-cost solution designed to be implemented in developing and transition countries (36)	
	• Valorisation of all new processed co-products in order to be economically and environmentally optimal (36)	
	• Including clients in the project management (27)	
	• Targeting the market of conscious clients (4, 29)	
	• Traceability, high quality standards and fair agriculture attract clients even if the products have a higher price than conventional ones (39)	
	• Designing processes that are more than pure alternatives; e.g. processes that are bio-based but also source of energy-savings or increased production capacity (15)	
	• Pro-active promotion of the project to obtain a permission to produce and receive public support (17)	
	• A vertical integration enables a strong IP and labelling strategy; it enables stronger branding, facilitates cross-industry cooperation and further innovation (37)	
(3) Organizational and spatial	• Geographical proximity of groups of stakeholders: industries, applied R&D and academia (3, 10), or of the primary sector (farmers) and the secondary sector (manufacturers) (1)	• Sufficient space is needed to set up a small biogas plant (23)
	• Development of an open technological platform for industrial scaling-up of biotechnology processes (10)	• Odour emission needs to be considered (depended on the local context and the baseline) when designing the concept of a biogas plant (11)
	• Available space to grow in the future (1)	• Seasonality alters the availability of by-products; thus, stocks must be carefully planned (transport, storage, processing) (29)
	• High efficiency infrastructures, local smart-grids and driven Industrial Symbiosis to reduce production costs in an Agro-industrial Park setting (1)	• If too far away from the production location, farmers may not benefit from the added value generated via the by-products (26)
	• Driven top-down strategy to benefit from efficient Industrial Symbiosis (1)	
	• Development of local areas by exploiting old industrial sites that are decommissioned (32)	
	• Successful public-private partnerships (5, 8, 12, 38)	
	• Available local agricultural or industrial by-products (2, 12, 35)	
	• Possibility of valorising multiple by-products when involving other local businesses (23)	
	• Mobilizing existing clusters (4, 8)	
	• Building biorefinery plants next to wastewater-treatment stations to reduce energy and water consumption through resource exchange (27)	
	• Successful collaboration between a company and farmers in different countries (33)	
	• Joint venture to develop strategic partnership (15)	
(4) institutional and legal	• Large strategic Public-Private Partnership between the EU and the Bio-based Industries Consortium (5)	• Fiscal incentives are critical for economic feasibility (31)
	• Region declared as 'agricultural development area', creation of conditions for business development under the condition that the processing is sustainable (31)	• Future remuneration of electricity (power) coming from anaerobic digestion carefully considered (2)

(*continued on next page*)

Table 1 (*continued*)

Category	Success Factors	Risk Factors
	• Allowance to use slaughterhouse by-products as substrate for biogas production (11)	• Public financial support is difficult to get for scaling up from pilot scale to full-scale size (2, 4)
	• The biogas branch is supported by states (Switzerland and EU) and the current strategy supports the use of alternative energies (23)	• Change in legislation might be a risk (26, 28)
	• Financial support by the European Union for research projects (28, 34)	• Dependency on public subsidies (8)
	• Feed-in tariffs or other financial mechanisms to promote producing electricity or bioenergy via anaerobic digestion (2, 39)	
	• Public financial support (6, 8, 26)	
(5) Environmental, social and cultural	• Setting-up a large facility/ cluster can only happen when local governments, citizens, entrepreneurs and NGOs are involved (1)	• High dependency of the society on fossil-based energy (1)
	• Creation of jobs in rural areas while developing technological know-how (8, 34)	• Resistance from third parties (31)
	• Hundreds of thousands of CO_2 equivalents saved per year (32)	• Biogas plants are sometimes not wanted in the landscape (23, 24)
	• Well-accepted processes (energy and material recovery from manure) in the local context (2)	
	• Very clean biofuel produced (12)	
	• Buying by-products from local farmers avoids throwing tons of co-products into the sea (33)	
	• Consumers become increasingly interested in ecological products (4, 9, 35)	
	• Transparency and traceability for an ethical and ecological production is appreciated and an important marketing argument (29)	
	• Winning prizes/awards facilitates promotion (11, 18, 21, 33, 39)	
	• Designing for sustainability from the start (17)	
	• Pro-active citizen awareness raising (17)	

manure. For the fourth category (institutional and legal), public subsidies and local public-private cooperation were considered as critical success factor, while changes in regulations for agricultural waste treatment were seen as a risk. Fifth (environmental, social and cultural), the generally increased awareness and interest of consumers and communities in ecological products including transparent and traceable bio-based production processes were perceived as favouring conditions. The public perception of 'green products and processes' also favour business development, in particular the fact that they may be locally produced and are exploiting nature-based functionalities. All factors that are reducing the environmental impact have had a positive impact if separately monitored, too. However, negative trade-offs may arise if considered from a wider perspective, e.g. from an acceptability or aesthetic point of view as for the case of biogas plants installed in landscapes (NIMBY syndrome). As shown transversally in the five categories, the local dimension of valorising agricultural waste via the involvement of local stakeholders such as governments, citizens, entrepreneurs and NGOs is important for all individual businesses, and more easily achieved in case local employment and engagement is created by the initiative.

(ii) Factors most often mentioned in interviews fit in category 2 (economic, financial and marketing), confirming the overall goal of businesses for ensuring economic and financial health, above environmental or social benefits also in the agricultural waste valorisation domain. This was followed by category 3 (organisational and spatial), indicating that agricultural waste and by-products valorisation is in most cases strongly depending on local multi-actor collaboration and territorial embeddedness. Then, factors from category 1 (technological and logistic) and 5 (environmental, social and cultural) were equally often cited, and a little less from 4 (institutional and legal factors); again, the local scale variables are underlined as key importance for a successful business.

These findings confirm that the success of circular business models for agricultural and by-products valorisation depends on both internal business model elements, but also on the external business eco-system, i.e. the micro- (local context) and macro-environment ((inter)national context), which set the boundary conditions for successful business operations. While the macro-environmental conditions are only to be appreciated by individual businesses, the micro-environmental conditions can be controlled and influenced. They are context-dependant, which means that business concepts that are successful in one context may fail in another. Therefore, it is very important to well understand the local and (inter)national contextual factors and their evolutions (like subsidies changing in time), legislative measures and restrictions. It should be noted that as we are dealing in this study with many cases from different regions and countries, it was beyond the scope of this study to describe and compare each area- or case-specific context in detail, however some tendencies are apparent such as the scale of operations. Particularly in the USA and Taiwan, one is dealing with large scale and international business activities, quite often technology-orientated, while in Europe, a business mix of large and small scale, international and local activities is observed. This corresponds with differences in local and national bioeconomy strategies, policies and subsidies, especially also in Europe (Priefer et al., 2017; FAO, 2018) ,[2] and with the general structure of the agricultural sector ranging from family-owned micro-enterprises and farms to multinationals (Dabbert et al., 2017). In order to be able to analyse and benchmark even very different local and regional cases, a set of indicators has recently been developed by the FAO (2018); results are not yet published. Hence, we have made the choice to highlight more general and recurrent, and on the other hand also specific statements concerning the agricultural waste valorisation activities. However, no claim concerning the

[2] https://www.biogasworld.com/news/biogas-legislations-funding-opportunities-start-looking/

generalizability of the identified success and risk factors to different contexts can be made due to potentially biased inputs from interviews and insufficient stakeholder's opinions.

Regarding the internal business model canvas elements, we see that success or risks are mainly dealing with the left-hand side of the model, including the value creation mechanisms, with key activities (logistics, storage, valorisation processes), key resources (raw materials, technological resources) and key partners (waste suppliers, public, research and logistic partners), as well as on the building blocks cost structure (economies of scales for clusters, joint investments in R&D and technologies) and revenue streams (price competitiveness). This implies that the success of circular business models in the agricultural domain is actually not primarily dependant on the type of value creation (problem solved by the value proposition, low or high-value products), nor on the customers or distribution or communication channels.

Results also suggest that the transition from linear chains to a circular economy in the agricultural sector let individual business models evolve towards more dynamic and integrated business models, with a high degree of interaction of all actors (i.e. public partners, companies, research institutes, and other stakeholders such as local communities, customers or consumers) in a local context (e.g. cases 1, 2, 10, 13, 24, 25, 31). Hence, their strategies are correlated and can be mutually influenced. This implies that not only the business model of an individual company is impacted, but even more, that new, more integrated business models are required in order to lead to a successful co-creation of value in a territorial circular economy. Examples of integrated business model types for agricultural waste and by-product valorisation are biogas plants, environmental biorefineries, upcycling entrepreneurship, agricultural cooperatives, support structures, and agroparks (Donner et al., 2020); only upcycling entrepreneurship is not bound by territorial limits, however, it takes them also very strongly into consideration. For all actors involved, this asks for open and flexible management and transparent communication, while respecting each other's position. Overall, there seems to be a positive attitude since many more success than risk factors have been mentioned.

(iii) We recommend farmers and agribusiness managers to be entrepreneurial and flexible in the sense that agricultural waste and by-products valorising activities concerning new products and new market sectors can be taken into account; hence learning from other businesses, also from other sectors, is recommended and in particular how these can be translated into new, pertinent value propositions. Moreover, a deep understanding of the contextual factors and their changes (like subsidies changing in time), of the typical agricultural characteristics (such as heterogeneity of resources, flexibility in production due to seasonality and environmental stress), and of the consequences for markets that are traditionally not facing large fluctuations in product quality outputs (e.g. as for synthetic/chemical products) is needed. Here, farmers and local agri-food producers have a competitive advantage as compared to outsiders, because dealing with those characteristics is their daily business. Knowing about the environmental impact in both positive and negative terms is required, as green products have a positive image, a wide spectrum of potentially new natural applications and hence can substantially well contribute to a green environment; it should be noted that green does not always mean positive environmental impact due to losses, off-flavours (malodour), accumulation of previously used pesticides, aesthetics of installations, etc. Thus, an approach should be developed that counteracts potential negative side-effects. An open and differentiating communication towards inhabitants and consumers is strongly recommended.

To conclude and resume this discussion section, the main results, their conceptual implications and management recommendations are highlighted in the following Table 2.

6. Conclusion

The study of 39 business cases valorising agricultural waste and by-products has resulted in a long list of critical success and risk factors, which could be classified in five categories: (1) technical and logistic, (2) economic, financial and marketing, (3) organisational and spatial, (4) institutional and legal, and (5) environmental, social and cultural factors. Findings have revealed that while several success factors are also crucial for circular business models in general, some are very specific for ones valorising agricultural waste and by-products. These factors are 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. Overall, the local context is directly impacting business models to become more dynamic and integrated with the involvement of other territorial players. The new, more dynamic and integrated business models allow valorising agricultural waste and by-products, closing material fluxes

Table 2
Main results, conceptual implications and management recommendations.

Category and citation ranking (+)	Specific agricultural success (+) and risk factors (-)	Conceptual implications	Management recommendations
(1) technical and logistic ++	+ innovative and proven biotechnologies for agro-waste conversion + flexible in and out logistics and storage facilities - specificities of agricultural resources	➢ importance of key conversion activities and resources (logistics, storage, technological resources, raw materials)	➢ understanding agricultural characteristics ➢ being aware of new market dynamics due to potentially large fluctuations in product quality outputs
(2) economic, financial and marketing ++++	+ economies of scale for clusters + co-investments in R&D - price competitiveness of new bio-based products	➢ high importance of cost structure (economies of scales for clusters, joint investments in R&D and technologies) and agreements on revenue streams (price competitiveness)	➢ being entrepreneurial and flexible, as agro-waste conversion activities concern new products and markets ➢ learning from other businesses and sectors
(3) organisational and spatial +++	+ partnerships - sufficient space with efficient infrastructure (clusters)	➢ high importance of key partners (waste suppliers, public, research and logistic partners)	➢ collaborating with different partners, searching for synergies
(4) institutional and legal +	+ public subsidies - agro-waste management regulations	➢ importance of the business eco-system (macro-environment)	➢ understanding the contextual factors and their changes
(5) environmental, social and cultural ++	+ involvement of local stakeholders + consumers' interest in bio-based products - resistance of third parties	➢ importance of the business eco-system (both micro- and macro environment)	➢ knowing about the (positive and negative) environmental impact ➢ communicating transparently with stakeholders

locally, hence responding to the ambitions of the circular economy. Besides, the local contexts also favour public-private partnerships, even including citizens as consumers of local products to be part of valorising agricultural waste and by-products.

Finally, the traditional thinking about the production of food and of other products as two different sectors is to be reconsidered in a local context and replaced by a debate about most efficiently exploiting agricultural waste and by-products without sacrificing the nutrient cycle necessary for sustainable farming and crop production. It should be underlined that food as a primary need always serves as a baseline, however this doesn't exclude valorisation pathways for agricultural waste and by-products following the value pyramid (Fig. 1). In addition, network, cluster and local development theory can be useful to further deepen these insights on circular business models in the agricultural sector concerning the types and usage of local resources, kind of collaboration and partnerships, joint investments and synergies, their embeddedness in specific socio-economic and environmental contexts and impact on sustainable territorial development. Moreover, a global, in-depth benchmarking of local initiatives with the relevant national bioeconomy strategies deserves attention to gain insights into the range of different circular business models, their dissimilarities but also synergies.

Credit author statement

Mechthild Donner (M.D.), Anne Verniquet (A.V.), Jan Broeze (J.B.), Katrin Kayser (K.K.), Hugo de Vries (H.V.) contributed to the conception of the study, the acquisition of data, the analysis of the data, the revision of the manuscript, and approved the final version of the manuscript. A. V. coordinated the collection of the data. M.D. and H.V. drafted the manuscript, the figures and tables.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Annex: List of cases studied within WP5 of the NOAW project

Case number	Country	Type of organisation	Status	Typology of initiative 1	Typology of initiative 2
1	Netherlands	Commercial enterprise / for profit	On-going	Agro Food and other industries	Clustered
2	Germany	Commercial enterprise / for profit	On-going	Centred around anaerobic digestion	Non-clustered
3	USA	Commercial enterprise / for profit	On-going	Agro Food and other industries	Non-clustered
4	France	Association / non for profit	On-going	Non-food industries	Non-clustered
5	Europe	Public private partnership	On-going	Agro Food and other industries	Non-clustered
6	France	Commercial enterprise / for profit	On-going	Agro Food only	Clustered
7	Hungary	Commercial enterprise / for profit	On-going	Agro Food only	Non-clustered
8	France	Association / non for profit	On-hold	Agro Food and other industries	Clustered
9	Poland	Commercial enterprise / for profit	On-going	Non-food industries	Non-clustered
10	France	Commercial enterprise / for profit	On-going	Agro Food and other industries	Clustered
11	Austria	Commercial enterprise / for profit	On-going	Centred around anaerobic digestion	Non-clustered
12	France	Public private partnership	On-going	Centred around anaerobic digestion	Non-clustered
13	Netherlands	Public private partnership	On-going	Agro Food and other industries	Clustered
14	Taiwan	Commercial enterprise / for profit	On-going	Agro Food and other industries	Non-clustered
15	USA	Commercial enterprise / for profit	On-going	Agro Food only	Non-clustered
16	Taiwan	Commercial enterprise / for profit	On-going	Non-food industries	Non-clustered
17	Switzerland	Commercial enterprise / for profit	On-hold	Agro Food only	Non-clustered
18	Taiwan	Commercial enterprise / for profit	On-going	Agro Food and other industries	Non-clustered
19	Taiwan	Commercial enterprise / for profit	On-going	Agro Food and other industries	Non-clustered
20	Taiwan	Commercial enterprise / for profit	On-going	Agro Food and other industries	Non-clustered
21	Taiwan	Commercial enterprise / for profit	On-going	Agro Food and other industries	Non-clustered
22	Taiwan	Commercial enterprise / for profit	On-going	Agro Food and other industries	Non-clustered
23	Switzerland	Commercial enterprise / for profit	On-going	Centred around anaerobic digestion	Non-clustered
24	Germany	Commercial enterprise / for profit	On-going	Centred around anaerobic digestion	Clustered
25	Sweden	Commercial enterprise / for profit	On-going	Agro Food and other industries	Clustered
26	France	Commercial enterprise / for profit	On-going	Agro Food and other industries	Non-clustered
27	Denmark	Commercial enterprise / for profit	On-going	Centred around anaerobic digestion	Non-clustered
28	Italy	Commercial enterprise / for profit	On-going	Centred around anaerobic digestion	Non-clustered
29	Switzerland	Commercial enterprise / for profit	On-going	Agro Food and other industries	Non-clustered
30	Denmark	Public private partnership	On-going	Centred around anaerobic digestion	Non-clustered
31	Netherlands	Commercial enterprise / for profit	On-going	Agro Food and other industries	Clustered
32	Italy	Commercial enterprise / for profit	On-going	Agro Food and other industries	Clustered
33	Germany	Commercial enterprise / for profit	On-going	Non-food industries	Non-clustered
34	Europe	Public private partnership	On-going	Agro Food and other industries	Non-clustered
35	Netherlands	Commercial enterprise / for profit	On-going	Agro Food only	Non-clustered
36	Switzerland to Vietnam and Brazil	Public private partnership	On-going	Agro Food and other industries	Non-clustered
37	Taiwan	Commercial enterprise / for profit	On-going	Non-food industries	Non-clustered
38	Norway	Public private partnership	On-going	Centred around anaerobic digestion	Non-clustered
39	Germany	Commercial enterprise / for profit	On-going	Agro Food and other industries	Non-clustered

References

Abecassis, J., de Vries, H., Rouau, X., 2014. New perspective for bio-refining cereals. Biofuels, Bioprod. Biorefinery 8, 462–474. https://doi.org/10.1002/bbb.1455.

Antikainen, M., Valkokari, K., 2016. A framework for sustainable circular business model innovation. Technol. Innovat. Manag. Rev. 6 (7), 5–12. http://timreview.ca/article/1000.

Asswad, J., Hake, G., Gómez, J.M., 2016. The Obstacles of Sustainable Business Model Innovations. Proceedings of the 2016 International Conference on Innovation Resources Management. Cape Town, South Africa, 18-20 May 2016.

Baden-Fuller, C., MacMillan, I.C., Morgan, M.S., 2010. Business models as models (editorial). Long Range Plann 43 (2–3), 143–145. https://doi.org/10.1016/j.lrp.2010.02.005.

Barros, M.V., Salvador, R., de Francisco, A.C., Piekarski, C.M., 2020. Mapping of research lines on circular economy practices in agriculture: from waste to energy. Renew. Sustain. Energy Rev. 131, 109958 https://doi.org/10.1016/j.rser.2020.109958.

Batstone, D.J., Virdis, B., 2014. The role of anaerobic digestion in the emerging energy economy. Curr. Opin. Biotechnol. 27, 142–149.

Bellamare, M.F., Çakir, M., Peterson, H.H., Novak, L., Rudi, J., 2017. On the measurement of food waste. Am. J. Agric. Econ. 99 (5), 1148–1158. https://doi.org/10.1093/ajae/aax034.

Berg, B.L., 2009. An Introduction to Content Analysis. In: Berg, B.L. (Ed.), Qualitative Research Methods for the Social Sciences. Allyn and Bacon, Boston, pp. 1–15.

Bocken, N.M., Short, S.W., Rana, P., Evans, S., 2014. A literature and practice review to develop sustainable business model archetypes. J. Clean. Prod. 65, 42–56. https://www.sciencedirect.com/science/article/pii/S0959652613008032.

Bocken, N.M., De Pauw, I., Bakker, C., van der Grinten, B., 2016. Product design and business model strategies for a circular economy. J. Ind. Prod. Eng. 33 (5), 308–320. https://doi.org/10.1080/21681015.2016.1172124.

Boons, F., Lüdeke-Freund, F., 2013. Business models for sustainable innovation: state-of-the-art and steps towards a research agenda. J. Clean. Prod. 45 (2013), 9–19. https://doi.org/10.1016/j.jclepro.2012.07.007.

Brundtland, G., Khalid, M., Agnelli, S., et al., 1987. Our Common Future: Report of the 1987 World Commission on Environment and Development. United Nations, Oslo.

Buzby, J.C., Farah-Wells, H., Hyman, J., 2014. The estimated amount, value, and calories of postharvest food losses at the retail and consumer levels in the United States. USDA-ERS Economic Information Bulletin, 121. www.ers.usda.gov/publications/eib-economic-information-bulletin/eib-xxx.aspx. Last accessed on 01/09/2020.

Caldeira, C., De Laurentiis, V., Corrado, S., van Holsteijn, F., Sala, S., 2019. Quantification of food waste per product group along the food supply chain in the European Union: a mass flow analysis. Resour. Conservat. Recycl. 149, 479–488. https://doi.org/10.1016/j.resconrec.2019.06.011.

Camacho-Otero, J., Boks, C., Pettersen, I., 2018. Consumption in the circular economy: a literature review. Sustainability 10 (8), 2758. https://doi.org/10.3390/su10082758.

Casadesus-Masanell, R., Ricart, J.E., 2010. From strategy to business models and onto tactics. Long Range Plann 43 (2–3), 195–215. https://doi.org/10.1016/j.lrp.2010.01.004.

Cervantes, G., Torres, L.G., Ortega, M., 2020. Valorization of agricultural wastes and Biorefineries: a way of heading. In: Salomone, R., Cecchin, A., Deutz, P., Raggi, A., Cutaia, L. (Eds.), Industrial Symbiosis for the Circular Economy. Strategies for Sustainability. Springer, Cham, pp. 181–194. https://doi.org/10.1007/978-3-030-36660-5_12.

Chaboud, G., Daviron, B., 2017. Food losses and waste: navigating the inconsistencies. Glob Food Sec 12, 1–7. https://doi.org/10.1016/j.gfs.2016.11.004.

Chesbrough, H., 2003. Open Innovation: The New Imperative for Creating and Profiting from Technology. Harvard Business Press, Boston.

Chesbrough, H., 2010. Business model innovation: opportunities and barriers. Long Range Plann 43 (2–3), 354–363.

Dabbert, S., Lewandowski, I., Weiss, J., Pyka, A. (Eds.), 2017. Knowledge-Driven Developments in the Bioeconomy: Technological and Economic Perspectives. Springer, Heidelberg.

Dahiya, S., Kumar, A.N., Shanthi Sravan, J., Chatterjee, S., Sarkar, O., Mohan, S.V., 2018. Food waste biorefinery: sustainable strategy for circular bioeconomy. Bioresour. Technol. 248, 2–12. https://doi.org/10.1016/J.BIORTECH.2017.07.176.

D'Amato, D., Droste, N., Allen, B., 2017. Green, circular, bioeconomy: a comparative analysis of sustainability avenues. J. Clean. Prod. 168, 716–734. https://doi.org/10.1016/j.jclepro.2017.09.053.

Donner, M., Gohier, R., de Vries, H., 2020. A new circular business model typology for creating value from agro-waste. Sci. Total Environ. 716, 137065 https://doi.org/10.1016/j.scitotenv.2020.137065.

Duque-Acevedo, M., Belmonte-Ureña, L.J., Cortés-García, F.J., Camacho-Ferre, F., 2020. Agricultural waste: review of the evolution, approaches and perspectives on alternative uses. Global Ecol. Conservat. 10.1016/j.gecco.2020.e00902.

EC - European Commission, 2015. Closing the Loop - an EU Action Plan for the Circular Economy. EC Brussels, Belgium. https://eur-lex.europa.eu/resource.html?uri=cellar:8a8ef5e8-99a0-11e5-b3b7-01aa75ed71a1.0012.02/DOC_1&format=PDF. Last accessed on 17/03/2020.

EC – European Commission, 2019. Report on the Implementation of the Circular Economy Action Plan. EC Brussels, Belgium. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52019DC0190&from=EN. Last accessed on 24/08/2020.

EIP Agri, 2017. Nutrient Recycling – final report. https://ec.europa.eu/eip/agriculture/sites/agri-eip/files/eip-agri_fg_nutrients_recycling_final_report_2017_en.pdf. Last accessed on 01/09/2020.

EMF - Ellen MacArthur Foundation, 2013. Towards the circular economy. Econ. Bus. Ration. Accelerat. Trans. https://www.ellenmacarthurfoundation.org/assets/downloads/publications/Ellen-MacArthur-Foundation-Towards-the-Circular-Economy-vol.1.pdf. Last accessed on 17/03/2020.

FAO – Food and Agriculture Organization of the United Nations, 2011. Global Food Losses and Food Waste – extent, Causes and Prevention. UN FAO, Rome. http://www.fao.org/3/a-i2697e.pdf. Last accessed on 25/08/2020.

FAO – Food and Agricultural Organisation of the United Nations, 2015. Food Wastage Footprint & Climate Change. UN FAO, Rome. http://www.fao.org/3/a-bb144e.pdf. Last accessed on 17/03/2020.

FAO – Food and Agricultural Organisation of the United Nations, 2018. Assessing the Contribution of Bioeconomy to Countries' Economy. UN FAO, Rome. http://www.fao.org/3/I9580EN/i9580en.pdf. Last accessed on 01/09/2020.

FUSIONS, 2016. Estimates of European food waste levels. Available online: https://www.eu-fusions.org/index.php/publications. Last accessed on 17/03/2020.

Geissdoerfer, M., Savaget, P., Bocken, N.M., Hultink, E.J., 2017. The Circular Economy–A new sustainability paradigm? J. Clean. Prod. 143, 757–768. https://doi.org/10.1016/j.jclepro.2018.06.240.

Geissdoerfer, M., Morioka, S.N., de Carvalho, M.M., Evans, S., 2018. Business models and supply chains for the circular economy. J. Clean. Prod. 190, 712–721. https://doi.org/10.1016/j.jclepro.2018.04.159.

Ghisellini, P., Cialani, C., Ulgiati, S., 2016. A review on circular economy: the expected transition to a balanced interplay of environmental and economic systems. J. Clean. Prod. 114, 11–32. https://doi.org/10.1016/j.jclepro.2015.09.007.

Golembiewski, B., Sick, N., Bröring, S., 2015. The emerging research landscape on bioeconomy: what has been done so far and what is essential from a technology and innovation management perspective? Innovat. Food Sci. Emerg. Technol. 29, 308–317. https://doi.org/10.1016/j.ifset.2015.03.006.

... Gontard, N., Sonesson, U., Birkved, M., Majone, M., Bolzonella, D., Celli, A., Schaer, B., 2018. A research challenge vision regarding management of agricultural waste in a circular bio-based economy Crit. Rev. Environ. Sci. Technol. 48 (6), 614–654. https://doi.org/10.1080/10643389.2018.1471957.

Hansen, E.G., Grosse-Dunker, F., Reichwald, R., 2009. Sustainability innovation cube - a framework to evaluate sustainability-oriented innovations. Int. J. Innovat. Manag. 13 (04), 683–713.

Homrich, A.S., Galvao, G., Abadia, L.G., Carvalho, M.M., 2018. The circular economy umbrella: trends and gaps on integrating pathways. J. Clean. Prod. 175, 525–543. https://doi.org/10.1016/j.jclepro.2017.11.064.

Horlings, L.G., Hinssen, J., 2014. Sustainable innovation in intensive animal husbandry; policy and public protests towards a mega-farm in the Netherlands. J. Commun. Stud. 7 (13), 125–145.

Jonker, J., 2012. New Business Models: an Explorative Study of Changing Transactions Creating Multiple Values. Jab management consultants bv, Doetinchem.

Jurgilevich, A., Birge, T., Kentala-Lehtonen, J., Korhonen-Kurki, K., Pietikäinen, J., Saikku, L., Schösler, H., 2016. Transition towards circular economy in the food system. Sustainability 8 (1), 69. https://doi.org/10.3390/su8010069.

Kalmykova, Y., Sadagopan, M., Rosado, L., 2018. Circular economy – From review of theories and practices to development of implementation tools. Resour. Conservat. Recycl. 135, 190–201. https://doi.org/10.1016/j.resconrec.2017.10.034.

Kirchherr, J., Reike, D., Hekkert, M., 2017. Conceptualizing the circular economy: an analysis of 114 definitions. Resour. Conservat. Recycl. 127, 221–232. https://doi.org/10.1016/j.resconrec.2017.09.005.

Laukkanen, M., Patala, S., 2014. Analysing barriers to sustainable business model innovations: innovation systems approach. Int. J. Innovat. Manag. 18 (06), 1–21. https://doi.org/10.1142/S1363919614400106.

Lewandowski, M., 2016. Designing the business models for circular economy - towards the conceptual framework. Sustainability 8 (43), 1–28. https://doi.org/10.3390/su8010043.

Linder, M., Williander, M., 2015. Circular business model innovation: inherent uncertainties. Bus. Strateg. Environ. 26 (2), 182–196. https://doi.org/10.1002/bse.1906.

Lüdeke-Freund, F., 2010. Towards a Conceptual Framework of "Business Models for Sustainability" (SSRN Scholarly Paper No. ID 2189922). Social Science Research Network, Rochester, NY.

Long, T.B., Looijen, A., Blok, V., 2018. Critical success factors for the transition to business models for sustainability in the food and beverage industry in the Netherlands. J. Clean. Prod. 175 (2018), 82–95. https://doi.org/10.1016/j.jclepro.2017.11.067.

Magretta, J., 2002. Why business models matter. Harv. Bus. Rev. 80, 3–8.

Massard, G., Jacquat, O., Wagner, L., Zürcher, D., 2013. International Survey On Eco-Innovation Parks - Learning from Experiences On the Spatial Dimension of Eco-Innovation. BAFU, B. f. U., Bundesamt für Umwelt BAFU, Swiss Confederation, p. 295.

Meadows, D.H., Meadows, D.L., Randers, J., Behrens, W., 1972. The Limits to Growth. A Report for the Club of Rome's Project on the Predicament of Mankind. Universe Books, New York.

Mentink, B., 2014. Circular business model innovation: a process framework and a tool for business model innovation in a circular economy. Master Thesis. University of Leiden, NL. https://repository.tudelft.nl/islandora/object/uuid%3Ac2554c91-8aaf-4fdd-91b7-4ca08e8ea621.

Micheaux, H., Aggeri, F., 2016. Innovation environnementale et création de valeur : emergence et conditions de développement de BM circulaires dans la filière DEEE. AIMS Conference. Lyon, France. September 2016. https://hal-mines-paristech.archives-ouvertes.fr/hal-01368036/document.

Millar, N., McLaughlin, E., Börger, T., 2019. The circular economy: swings and roundabouts? Ecol. Econ. 158, 11–19. https://doi.org/10.1016/j.ecolecon.2018.12.012.

Moraga, G., Huysveld, S., Mathieux, F., Blengini, G.A., Alaerts, L., Van Acker, K., De Meester, S., Dewulf, J., 2019. Circular economy indicators: what do they measure? Resour. Conservat. Recycl. 146, 452–461. https://doi.org/10.1016/j.resconrec.2019.03.045.

Morales, E.M., Diemer, A., Cervantes, G., Carrillo-González, G., 2019. "By-product synergy" changes in the industrial symbiosis dynamics at the Altamira-Tampico industrial corridor: 20 Years of industrial ecology in Mexico. Resour. Conservat. Recycl. 140, 235–245. https://doi.org/10.1016/j.resconrec.2018.09.026.

Murray, A., Skene, K., Haynes, K., 2017. The circular economy: an interdisciplinary exploration of the concept and application in a global context. J. Bus. Ethics 140 (3), 369–380. https://doi.org/10.1007/s10551-015-2693-2.

Obi, F.O., Ugwuishiwu, B.O., Nwakaire, J.N., 2016. Agricultural waste concept, generation, utilization and management. Nigerian J. Technol. 35 (4), 957–964.

OECD, 1997. Glossary of Environment Statistics, Studies in Methods, Series F, No. 67. United Nations, New York.

Ometto, A.R., Ramos, P.A.R., Lombardi, G., 2007. The benefits of a Brazilian agro-industrial symbiosis system and the strategies to make it happen. J. Clean. Prod. 15 (13–14), 1253–1258. https://doi.org/10.1016/j.jclepro.2006.07.021.

Osterwalder, A., Pigneur, Y., 2010. Business Model Generation: a Handbook for Visionaries, Game changers, and Challengers. John Wiley & Sons, Hoboken, New Jersey.

Papargyropoulou, E., Lozano, R., Steinberger, J.K., Wright, N., Bin Ujang, Z., 2014. The food waste hierarchy as a framework for the management of food surplus and food waste. J. Clean. Prod. 76, 106–115. https://doi.org/10.1016/j.jclepro.2014.04.020.

Pawelczyk, A., 2005. EU policy and legislation on recycling of organic wastes to agriculture. ISAH 1, 64–71.

Pellis, A., Cantone, S., Ebert, C., Gardossi, L., 2018. Evolving biocatalysis to meet bioeconomy challenges and opportunities. N. Biotechnol. 40, 154–169.

Priefer, C., Jörissen, J., Frör, O., 2017. Pathways to shape the bioeconomy. Resources 6 (1), 1–10. https://doi.org/10.3390/resources6010010.

Reike, D., Vermeulen, W.J., Witjes, S., 2018. The circular economy: new or refurbished as CE 3.0? Exploring controversies in the conceptualization of the circular economy through a focus on history and resource value retention options. Resour. Conservat. Recycl. 135, 246–264. https://doi.org/10.1016/j.resconrec.2017.08.027.

Rennings, K., 2000. Redefining innovation - eco-innovation research and the contribution from ecological economics. Ecol. Econ. 32 (2), 319–332. https://doi.org/10.1016/S0921-8009(99)00112-3.

Rizos, V., Behrens, A., Van der Gaast, W., Hofman, E., Ioannou, A., Kafyeke, T., Flamos, A., Rinaldi, R., Papdelis, S., Hirschnitz-Gabers, M., Topi, C., 2016. Implementation of circular economy business models by small and medium-sized enterprises (SMEs): barriers and enablers. Sustainability 8 (11), 1–18. https://doi.org/10.3390/su8111212.

Ronzon, T., Sanjuán, A.I., 2020. Friends or foes? A compatibility assessment of bioeconomy-related Sustainable Development Goals for European policy coherence. J. Clean. Prod. 254, 119832 https://doi.org/10.1016/J.JCLEPRO.2019.119832.

Schaltegger, S., Hansen, E.G., Lüdeke-Freund, F., 2016. Business models for sustainability: origins, present research, and future avenues. Organ. Environ. 29 (1), 3–10. https://doi.org/10.1177/1086026615599806.

Schieb, P.A., Lescieux-Katir, H., Thénot, M., Clément-Larosière, B., 2015. Biorefinery 2030. Future Prospects for the Bioeconomy. Springer, Berlin and Heidelberg.

Smeets, P.J., 2011. Expedition agroparks: Research by Design Into Sustainable Development and Agriculture in the Network Society. Wageningen Academic Publishers, Wageningen.

Spaeth, J., 2014. Biorefining – Country Report United States 2014. https://www.iea-bioenergy.task42-biorefineries.com/upload_mm/1/e/4/d73112c0-1304-4aaf-8854-db61ce8292a1_IEA_Task_42_USA_Country_Report_2014.pdf. Last accessed on 26/08/2020.

Stadler, T., Chauvet, J.M., 2018. New innovative ecosystems in France to develop the Bioeconomy. N. Biotechnol. 40, 113–118. https://doi.org/10.1016/j.nbt.2017.07.009.

Stubbs, W., Cocklin, C., 2008. Conceptualizing a "sustainability business model". Organ. Environ. 21 (2), 103–127. https://doi.org/10.1177/1086026608318042.

Teece, D.J., 2010. Business models, business strategy and innovation. Long Range Plann. 43 (2–3), 172–194.

Teigiserova, D.A., Hamelin, L., Thomsen, M., 2020. Towards transparent valorization of food surplus, waste and loss: clarifying definitions, food waste hierarchy, and role in the circular economy. Sci. Total Environ. 706, 136033 https://doi.org/10.1016/J.SCITOTENV.2019.136033.

Tuck, C.O., Pérez, E., Horváth, I.T., Sheldon, R.A., Poliakoff, M., 2012. Valorization of biomass: deriving more value from waste. Science 337 (6095), 695–699. https://doi.org/10.1126/science.1218930.

Tura, N., Hanski, J., Ahola, T., Ståhle, M., Piiparinen, S., Valkokari, P., 2019. Unlocking circular business: a framework of barriers and drivers. J Clean Prod 212, 90–98. https://doi.org/10.1016/j.jclepro.2018.11.202.

Ünal, E., Urbinati, A., Chiaroni, D., Manzini, R., 2019. Value Creation in Circular Business Models: the case of a US small medium enterprise in the building sector. Resour. Conservat. Recycl. 146, 291–307. https://doi.org/10.1016/j.resconrec.2018.12.034.

UNEP – United Nations Environment Programme, 2011. Decoupling natural resource use and environmental impacts from economic growth, A Report of the Working Group on Decoupling to the International Resource Panel. Online: https://sustainabledevelopment.un.org/content/documents/Decoupling_Report_English.pdf.

Vea, E.B., Romeo, D., Thomsen, M., 2018. Biowaste valorisation in a future circular bioeconomy. Procedia 69, 591–596.

Velenturf, A.P., Archer, S.A., Gomes, H.I., Christgen, B., Lag-Brotons, A.J., Purnell, P., 2019. Circular economy and the matter of integrated resources. Sci. Total Environ. 689, 963–969. https://doi.org/10.1016/j.scitotenv.2019.06.449.

Mohan, Venkata, V., S., Nikhil, G.N., Chiranjeevi, P., Reddy, C.N., Rohit, M.V., Kumar, A. N., Sarkar, O., 2016. Waste biorefinery models towards sustainable circular bioeconomy: critical review and future perspectives. Bioresour. Technol. 215, 2–12.

Vermunt, D.A., Negro, S.O., Verweij, P.A., Kuppens, D.V., Hekkert, M.P., 2019. Exploring barriers to implementing different circular business models. J. Clean. Prod. 222, 891–902. https://doi.org/10.1016/j.jclepro.2019.03.052.

Verniquet, A., de Souza, Broeze, A., Groot, J., de Vries, J., Donner, H., Kayser, K., M., 2018. Review paper on business and cluster concepts. NoAW project Deliverable 5.1.

Voss, C., Tsikriktsis, N., Frohlich, M., 2002. Case research in operations management. Int. J. Operat. Prod. Manag. 22 (2), 195–219. https://doi.org/10.1016/j.jclepro.2018.11.202.

Yin, R.K., 2009. Case Study research: Design and Methods (applied Social Research Methods). Sage, London and Singapore.

Yu, F., Han, F., Cui, Z., 2015. Evolution of industrial symbiosis in an eco-industrial park in China. J. Clean. Prod. 87, 339–347. https://doi.org/10.1016/j.jclepro.2014.10.058.

Yuan, Z., Bi, J., Moriguichi, Y., 2006. The circular economy: a new development strategy in China. J. Ind. Ecol. 10 (1-2), 4–8. https://doi.org/10.1162/108819806775545321.

Zott, C., Amit, R., 2010. Business model design: an activity system perspective. Long Range Plann. 43 (2–3), 216–226. https://doi.org/10.1016/j.lrp.2009.07.004.

Zott, C., Amit, R., Massa, L., 2011. The business model: recent developments and future research. J. Manage. 37 (4), 1019–1042. https://doi.org/10.1177/0149206311406265.