

Review

The Role of Circular Economy Strategies in Promoting Sustainability in the Agri-Food Sector: Insights from the Valencian Community

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Abstract

The agri-food sector plays a pivotal role in the global economy, requiring innovative and efficient practices to ensure long-term sustainability. The paper aims to identify and analyse circular economy strategies applicable to the agri-food sector through Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis. The analysis considers the legislative context at European, Spanish, and regional levels, specifically focusing on the Valencian Community. The study underscores the need for collaborative action involving public and private entities, technological advancements, and substantial investments in human and economic capital. The paper concludes by summarising the main findings and emphasising the importance of implementing circular economy strategies to simultaneously achieve economic development, environmental conservation, and food demand fulfilment in the agri-food sector.

Keywords: circular economy; agri-food sector; food waste; sustainability; industrial symbiosis



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1. Introduction

Rapid population and industrial growth have led to a disproportionate consumption of natural resources, in many cases exceeding their regenerative capacity or taking them to critical values [1,2]. Industrial and economic progress has led to the establishment of a society based on the consumption of vast quantities of resources, which in turn generates a large volume of waste, endangering the sustainability of the environment and our own economic system [3,4].

Particularly, the agri-food sector is at the core of the global sustainability agenda due to its substantial contribution to environmental degradation, resource consumption, and socio-economic dynamics. The agri-food industry exerts a considerable environmental footprint, stemming from multiple unsustainable practices along its value chain. Among the most pressing concerns is the inefficient application of fertilisers, often resulting in nutrient imbalances and runoff, as well as the overuse of pesticides, which contribute to soil and water contamination and increased resistance in pests and pathogens [5–7]. Furthermore, the sector faces significant challenges in managing both organic and inorganic waste generated during agricultural and industrial processes, with inadequate waste treatment practices exacerbating environmental degradation [8,9]. Compounding these issues are the high levels of water consumption and substantial energy requirements inherent to many agri-food operations,

particularly in irrigation, processing, and transportation stages [10–12]. Collectively, these practices contribute to climate change, with agricultural production alone estimated to be responsible for up to 80% of the carbon emissions associated with food systems and accounting for approximately 14% to 24% of total global greenhouse gas emissions [13]. These figures underscore the urgent need to implement transformative measures aimed at enhancing the sustainability of agri-food systems.

Given this situation, the application of circular economy principles has emerged as a necessary transformation pathway to enhance the sustainability and resilience of agri-food systems [14]. Circular Economy strategies aim to reconfigure current economic models towards resource efficiency and recovery, promoting the transition to closed-loop systems where waste is minimised and materials are continuously reintegrated into the production cycle [15–18].

This paradigm shift is linked to the principle of sustainability [19,20], which aims not only to preserve the environment, but also to ensure the social and economic well-being of both present and future generations [18]. Thus, the circular economy recognises the intrinsic relationship that exists between human well-being, economic development and the state of the environment, which is why it is presented as a strategy for achieving a sustainable production system that simultaneously guarantees economic development and the conservation of natural resources [15,21,22]. To advance sustainability in the agri-food sector, it is therefore necessary to integrate environmental and socio-economic considerations into decision-making processes, promote sustainable supply chain management, and identify strategic intervention points such as waste reduction, resource efficiency, and responsible consumption.

The agri-food sector is a fundamental component of the global economic structure [23]. It encompasses an extensive network of actors, from agricultural producers to distributors, all working collaboratively to ensure the efficient production, processing and distribution of food products. The synergy and cooperation links involved in this chain not only benefits the individual actors but also generates a positive impact on the overall economy, promoting employment and stimulating economic development, exerting a significant influence on the economic stability and dynamics of the region and the country as a whole [24,25]. To ensure and maintain the economic development and stability of this sector, it is necessary to drive innovation and improve efficiency at each stage of the food chain through the use of sustainable technologies and the implementation of practices that strengthen the resilience and long-term sustainability of the sector [24,26]. The implementation of the circular economy in the agri-food sector is extremely complex, as it requires the joint action of multiple actors, including both public and private entities, various companies, technologies and a large initial investment in both human and economic capital that must be managed efficiently to achieve the maximum benefit. All this represents a considerable challenge, but the long-term benefits of the new model are innumerable, both from an environmental perspective and in economic and social terms.

To drive circular economy initiatives within the agri-food sector, it is essential to acknowledge that no single or “ideal” model can be uniformly applied across the entire sector due to its inherent complexity [27]. Accordingly, various assessment and monitoring approaches have been developed to evaluate circular economy-related initiatives. Among these are Life Cycle Assessment (LCA), which evaluates the environmental impacts of products and processes [28]; Water Footprint Analysis, which examines the total volume of water required to produce goods or services [29–31]; and Life Cycle Energy Assessment (LCEA), which focuses on total energy consumption and the associated emissions [22]. Material Flow Analysis (MFA) quantifies the movement and presence of materials within a defined system, such as a city, industry, or ecosystem, while Data Envelopment Analysis

(DEA) and Environmentally Extended Input-Output Analysis (EEIOA) provide analytical frameworks that integrate environmental data into economic input-output models [24,32]. However, these methodologies are predominantly data-driven and may not sufficiently support the initial planning stages of circular economic implementation within specific sectors. For this purpose, strategic analysis tools are required to evaluate the sectoral context and define coherent pathways for circular economy advancement. In this study, a Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis is applied to provide a rational and practical evaluation of the most suitable practices for the agri-food sector.

The integration of circular economy strategies with the outcomes of the SWOT analysis offers a comprehensive understanding of both the constraints and driving forces shaping the transformation of the agri-food sector. Unlike other studies focused exclusively on environmental or economic diagnostics of the agri-food sector, previously mentioned, the present work offers an integrated strategic approach, combining a systemic view of the agri-food sector with a forward-looking logic that enables the formulation of targeted strategic actions aligned with circular economic principles and long-term sustainability goals. This strategic framework is the initial stage of the development of structured action plans, characterised by clearly defined objectives and targeted measures aligned with contextual challenges and opportunities, thereby enabling a more efficient allocation of human and financial resources. Based on the previous premises, this study aims to address the following research questions:

- What strategic approaches can facilitate the transition of the agri-food sector towards a more sustainable model based on the principles of the circular economy?
- How can the agri-food sector make use of its structure and resources to create synergies that enhance the efficient use of materials, water, and energy?
- What mechanisms can strengthen the resilience of the agri-food system in the face of global risks such as climate change, water scarcity, or rural depopulation?

2. Legislation About the Implementation of Circular Economy in the Agri-Food Sector

2.1. European Legislation

The role that the European Union (EU) has played in highlighting the need to ensure a secure supply of resources and their efficient use to ensure that businesses and economies thrive is noteworthy. Over the last decade, the EU has urged governments and businesses around the world to implement strategies based on the circular economy model. As a result, the European Commission has been working for several years on the development of plans, packages and proposals aimed at transforming the current linear economic model into a circular one. The process of transition towards a circular economy model by the European Union started in 2014 with the communication ‘Towards a circular economy: a zero waste agenda for Europe’, with the aim of reducing waste generated. This publication was followed by the ‘Action Plan for a circular economy in Europe’ published in 2015, in which the European Commission proposed a series of measures that go beyond waste reduction and affect all stages of the product life cycle.

In 2018, the ‘Circular Economy Legislative Package’ was presented, highlighting the ‘European Strategy for Plastics in a Circular Economy’ [33] and the ‘Sustainability Strategy for Chemicals’ [34–36]. With the aim of mainstreaming the implementation of the circular economy, the ‘New Circular Economy Action Plan for a cleaner and more competitive Europe’ [37] was recently published in 2020, which is a key element in the European Green Deal [38], Europe’s new agenda for sustainable growth. These measures to promote the recovery of the environment and ensure the future sustainability of European society in the context of the fight against climate change are considered essential and pressing for

all member states [39]. The following figure (Figure 1) presents a visual summary of the European Green Deal's strategic framework, with a focus on the Circular Economy Action Plan (CEAP). It highlights the overarching goals of climate neutrality and sustainable transformation, outlines the main objectives of the CEAP, such as waste reduction and resource efficiency, and identifies key sectors where circular economy principles are to be implemented, including food, water, and nutrients.



Figure 1. Overview of the Circular Economy Action Plan within the European Green Deal, highlighting key objectives and priority sectors. Source: Own elaboration.

Within the framework of the EU Circular Economy Action Plan, the agri-food sector has been identified as one of the key priority areas for implementing circular strategies. Its close connection to natural ecosystems, high resource intensity, and potential for waste recovery make it a strategic sector for achieving a regenerative and resilient economy [40]. The circular economy redefines the agri-food system by:

- Transforming organic waste, such as food surpluses, crop residues, and manure, into biogas and organic fertilisers through anaerobic digestion.
- Regenerating soils via composting and nutrient cycling, reducing reliance on synthetic inputs.
- Reducing food loss and waste through redistribution, transformation into new products, or recovery of valuable compounds.
- Promoting local, regenerative, and low-impact farming practices to close nutrient and resource loops.

By shifting from a linear model to a circular one, the agri-food sector can significantly reduce environmental pressures, enhance food system resilience, and contribute to the EU's climate neutrality and biodiversity goals. Implementing circularity in this sector is not only necessary it is urgent. It calls for collaboration across the value chain, from farmers to processors, distributors, and consumers, supported by policies, innovation, and education. This approach is illustrated in Figure 2, through a diagram adapted from the Ellen MacArthur Foundation's 'butterfly diagram' [18].

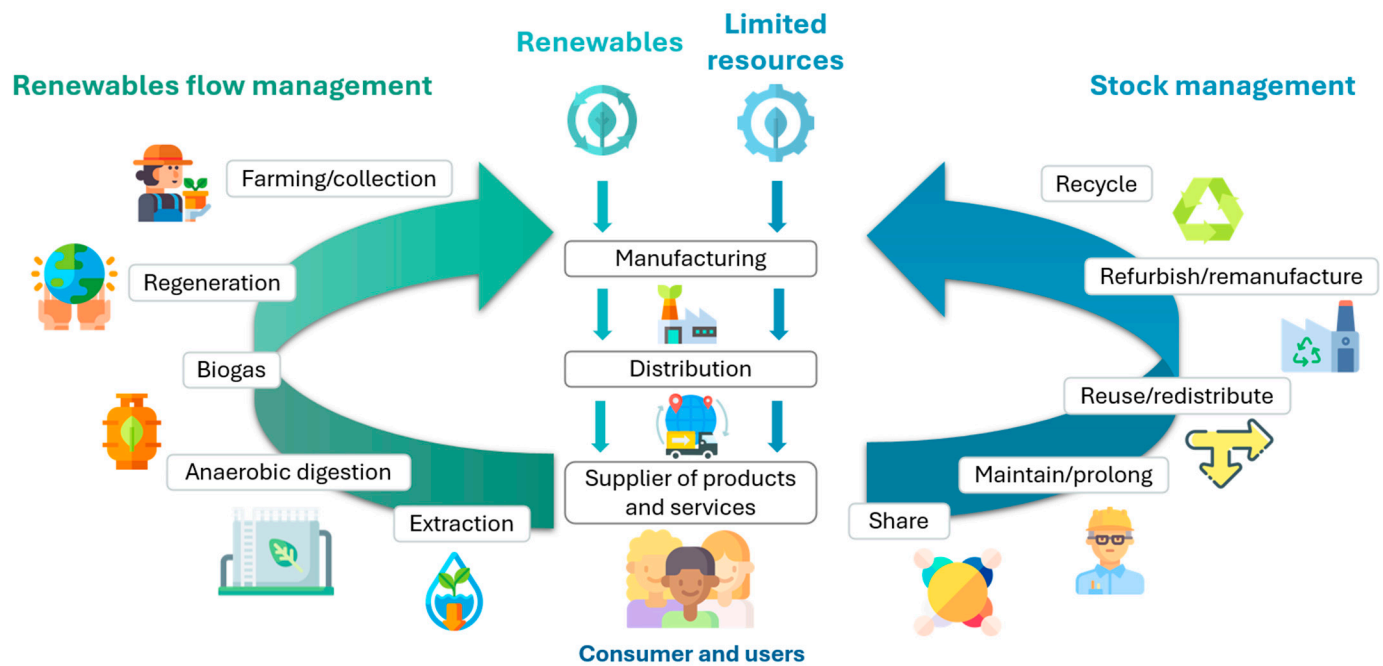


Figure 2. Circular economy model for the agri-food sector, adapted from the Ellen MacArthur Foundation’s butterfly diagram to illustrate biological and technical cycles specific to food systems. Source: Own elaboration.

2.2. Spanish Legislation

With regard to the Spanish legislation, since the implementation of Law 10/2000 in the Valencia Region, there have been significant changes in this legislation, notably Law 10/2000, on waste and contaminated soils, which transposed Directive 2008/98/EC and established the legal bases at national level, and more recently, Royal Decree 646/2020, which transposed Directive 2018/850, focused on landfill waste disposal. In addition, in 2016, the Spanish government approved the State Waste Framework Plan 2016–2022, defining operational targets to comply with Law 20/2011 and boost regional waste planning, aligning the contributions of the autonomous communities with national targets. In June 2020, the Council of Ministers approved the Spanish Strategy on Circular Economy, known as “Spain Circular 2030”, marking an important milestone in the promotion of sustainable practices. Finally, the recent approval of Law 7/2022 on waste and contaminated land to promote the circular economy completes the fundamental legal framework in this area, further consolidating the focus on the sustainable management of waste and contaminated land.

2.3. Regional Legislation in the Valencian Community

In view of the need to protect the environment and adapt the economic model in the fight against climate change, as well as to comply with European and national objectives on waste and the circular economy, it is essential to introduce new regional legislation in the Valencia Region to replace the now obsolete Law 10/2000, namely Law 5/2022, of 29 November, of the Generalitat, on waste and contaminated soils for the promotion of the circular economy in the Valencia Region. This law aims to promote the circular economy in the region and to apply circular economy criteria in waste management. It also seeks to boost waste prevention and reduction, preparation for reuse and recycling, with a special focus on household and commercial waste, which is mainly the responsibility of local administrations. Most of the law is dedicated to the prevention and proper management of these wastes, especially light packaging, such as beverage bottles, which are crucial to meet the targets set in European, national and regional waste regulations.

This law details the waste hierarchy and the principles of self-sufficiency and proximity in waste management, and regulates the right of access to information, participation and access to justice for citizens in waste matters and the application of the “polluter pays” principle. This law puts in place the necessary structures and financial resources to ensure that waste and circular economy policy in the Valencia Region is effectively implemented. An important innovation is the creation of the Valencian Waste and Circular Economy Agency, which will be a governmental entity with responsibilities in this area. Under the supervision of the Valencian Waste and Circular Economy Agency, the Waste and Circular Economy Environmental Fund is established, which aims to finance the actions carried out by the regional government to implement its waste and circular economy policy. It also seeks to support the implementation of the measures proposed in this law by other public entities and companies involved in waste reduction and management.

Moreover, this law addresses the planning of waste policy in the Valencia Region in order to comply with the guidelines established at state and European level. This includes waste prevention programmes at regional and local level, the Integrated Waste Plan of the Valencia Region (PIRCV), supra-municipal planning instruments, and local waste collection plans. In addition, economic and fiscal measures are established to encourage the prevention, reuse and recycling of waste. As well as encouraging the purchase of durable, reusable or recyclable products in public procurement. Emphasis is placed on environmental education, including awareness-raising on proper product management and waste prevention. The law requires 1% of the cost of waste collection and treatment contracts to be spent on environmental education and training and promotes collaboration with provincial councils. From 2024, local and waste management authorities must have environmental education programmes in order to access aid from the Generalitat Valenciana for waste management.

Another aspect on which this new regulation focuses is waste prevention and the establishment of minimum waste reduction targets, allowing the Waste Prevention Programme of the Valencia Region, included in the Integral Waste Plan of the Valencia Region, to establish stricter targets than state regulations, especially for electronic appliances, batteries, textiles, furniture, packaging, construction materials, and others, without contravening basic state regulations. In order to achieve this objective, prevention measures are promoted, including the adoption of sustainable and circular production and consumption patterns, the promotion of efficient product design and manufacturing, the reuse, repair and reduction in food waste, as well as the donation of food. Measures are also taken to prevent and reduce litter in different natural, agricultural, peri-urban and marine environments. Bulk sales and the use of reusable packaging are promoted, and the destruction or disposal in landfills of unsold non-perishable products, such as textiles, toys or electrical appliances, is prohibited, encouraging their reuse. As well as encouraging the sale and use of reusable beverage containers.

This law on waste and contaminated land for the promotion of the circular economy places special emphasis on waste prevention in the food industry at all stages, from production to final consumption. In addition, it establishes that primary production companies, food industries and distribution must prioritise the donation of unsold food, its use in animal feed, transformation into other products or recycling, and only as a last resort is it allowed to be disposed of. The law also recognises the rights of consumers to receive information on food waste prevention, to take back uneaten food from restaurants, and includes the promotion of civic projects to raise awareness and prevent food waste.

With regard to the management and reduction in the production and consumption of packaging, this law seeks to encourage the sale and use of reusable beverage containers, promoting their use in food establishments, both physical and online. One of the lines of

action is focused on promoting the use of tap water in catering and the availability of free drinking water in all public buildings, minimising the use of disposable water bottles and guaranteeing access to drinking water as an essential human right.

Another aspect, closely related to the food industry, that is addressed in this law is the use of packaging that is not considered packaging and that is difficult or impossible to recycle. In the Valencian Community, it is forbidden to label as “packaging” or similar plastic bags and wrappings that do not comply with state regulations and that are not recyclable according to available technologies, unless they are under extended producer responsibility or integrated management systems. This measure aims to reduce the inefficiency of waste management systems and prevent the disposal of these materials in landfills or in the environment. In addition, a number of conditions for the placing on the market of packaging and disposable containers are specified, including restrictions on plastic bags and non-recyclable packaging.

Table 1 below provides a summary of various European national and regional instruments related to the circular economy.

Table 1. Summary of the Circular economy policy instruments at European, National, and Regional level.

	Name of the Instrument	Description
European	Towards a Circular Economy: A Zero Waste Programme for Europe (2014)	Initial communication from the European Commission marking the beginning of the circular economy transition.
	Circular Economy Action Plan (2015)	First official action plan; addresses all stages of the product life cycle.
	Circular Economy Legislative Package (2018)	Legislative package. Includes the Strategy for Plastics and the Chemicals Sustainability Strategy.
	European Strategy for Plastics in a Circular Economy (2018)	Promotes plastic recycling, reduction, and sustainable design.
	Sustainability Strategy for Chemicals	Ensures the safety and sustainability of chemicals in the circular economy context.
	New Circular Economy Action Plan (2020)	Reinforces CEAP within the framework of the European Green Deal; prioritises sustainable design and responsible consumption.
	European Green Deal	EU roadmap for sustainable growth; circular economy is one of its key pillars.
National (Spain)	Law 10/1998 on Waste (Spain)	Early waste management law, later replaced by more recent legislation.
	Law 22/2011 on Waste and Contaminated Soils	Legal framework for waste management and pollution prevention.
	State Waste Management Framework Plan (PEMAR) 2016–2022	National operational plan to achieve circular economy targets in waste management.
	Royal Decree 646/2020 on Landfill Disposal	Transposes Directive 2018/850 on landfill waste disposal.
	Spanish Circular Economy Strategy “Spain Circular 2030”	National strategy to promote circular practices up to the year 2030.
	Law 7/2022 on Waste and Contaminated Soils for a Circular Economy	Replaces previous laws and strengthens the circular economy framework at the national level.

Table 1. Cont.

	Name of the Instrument	Description
Regional (Valencian Community)	Law 10/2000 on Waste and Contaminated Soils (Valencia)	Original regional law, now replaced by a new legal framework.
	Law 5/2022 on Waste and Contaminated Soils for the Promotion of the Circular Economy	New regional law aligning European and national guidelines with the Valencian context.
	PIRCV—Integrated Waste Plan of the Valencian Community	Regional waste management planning instrument with a circular approach.
	Waste Prevention Programme of the Valencian Community	Programme that sets stricter waste reduction targets than national standards.
	Valencian Waste and Circular Economy Agency	Government entity responsible for implementing circular economy and waste policy in the region.
	Waste and Circular Economy Environmental Fund	Financial tool to support regional circular economy and waste reduction actions.

3. Exploring the Spanish Agri-Food Sector: The Case of the Valencian Community

This section presents a comprehensive overview of the agri-food sector, with particular emphasis on the specific context of the Valencian Community. The agri-food sector plays a transcendental role at a global level, since it is crucial to satisfy the food demands of the world's population, but the relevance of this sector not only lies in its nutritional implications, but also in its influence on the economy at an international [41]. The agri-food economic system encompasses a wide network of diverse workers and companies that ensure the production, processing, distribution and sale of food, generating a large number of jobs. It is estimated that in the European Union alone this sector provides employment for 44 million people [42].

In Spain, it is estimated that the agri-food sector alone contributes around 11% of GDP [43], making it a fundamental element of our economy. Within the sector, it is worth highlighting the significant role of primary production, which represents 12% of the EU total, consolidating our country as the fourth most important producer of the EU member states, according to Eurostat statistics for 2017. In terms of exportation, Spain also stands out as one of the countries that exports the most foodstuffs, ranking fourth in the EU and eighth worldwide.

However, at national level, the agri-food sector not only plays a key role in terms of its contribution to the GDP, but also has a positive influence on other sectors. It is recognised as a strategical sector in our country, as it has broad social implications by providing employment for a vast amount of people. It is also an integral part of our culture, traditions and gastronomy, and has an impact on the configuration of the landscape. Although it is presented as a very consolidated and relevant sector, compared to other sectors, it is also a very vulnerable due to its own characteristics [44–46]. As we will see below, one of the sector's weaknesses lies precisely in the large number and diversity of actors involved with very different backgrounds and needs. In addition to this fragmentation of the sector, there are other factors such as the constant rise in production costs, whether fixed or variable, that jeopardise the stability of the sector.

Next, the specific characteristics of the different actors involved in the agri-food sector will be described:

- Primary production

Primary production covers a wide range of economic activities linked to the collection and harvesting of prime materials, such as agriculture, livestock and fishing. It is worth

mentioning that on a national level, primary production has been one of the main economic engines of our country, mainly highlighting the vegetables, fruits, meat and fish production market. However, the most important sector is undoubtedly agriculture, as Spain contributes nearly the 12% of the European agricultural production value and more than the 17% of its income [43]. Despite its positive contribution to the economy, the Spanish agricultural sector is the second largest contributor to greenhouse gas emissions among diffuse sectors, behind the transport sector [47,48]. In order to reverse this situation and mitigate the environmental impact generated by the agroindustry, it is necessary to implement more sustainable agricultural practices that guarantee the economic growth while preserving and protecting the environment. However, this is not the only challenge that the agricultural sector must face; there are other issues such as the ageing of the farming population, the rural exodus to the cities and water scarcity that need to be addressed [49].

- Food transport, processing and storage.

Once the products harvested and collected in the previous stage are obtained, then they are processed and stored for their subsequent consumption. In turn, just like the primary sector, the current stage is composed of different kinds of industries or subsectors (meat industry, fishing industry, milk production, bakery products, oils, etc.) with different impacts on the economy. At European level, the food and drink sector is a source of employment for 4.2 million people and contributes to 1.7% of the EU's gross value added [43]. The relevance of this sector is also present in Spain, standing out for being the main global producer and exporter of olive oil, consolidating its position as a leader in this market, and the main fruit and vegetable exporting country at European level and one of the three top global exporters along with China and the U.S.; according to the data offered by the Spanish Ministry of Agriculture, Fisheries and Food.

As far as the food/beverage sector is concerned, it is an extremely important economic component in the Valencian Community. According to data from the DIRCE (Central Directory of Companies) presented at the Spanish National Institute of Statistics (INE), in 2017 there were approximately 2169 companies associated with this sector, generating a total of 32,479 jobs, according to data from the Social Security in 2016. Figure 3 illustrates the structural composition of the agri-food industry by showing the relative weight of each manufacturing activity. This distribution helps to understand the sector's internal dynamics and supports the identification of strategic priorities. As can be observed the most prominent subsectors are the manufacture of bakery products and food pastas, which accounts for approximately 38.97% of the total, and the manufacture of other food products, representing 20.84%. Combined, these two categories encompass nearly 60% of the industry, underscoring their strategic relevance in terms of production volume, economic contribution, and potential leverage for transformative interventions. Although less represented in relative terms, the remaining subsectors also present opportunities for targeted circular practices.

Despite the existence of significant changes within the sector in terms of product innovation and the implementation of advanced technologies and human capital training in the processes, which improve the efficiency of the sector, one of the weak points of the food sector is the deficit in the implementation of strategies based on the circular economy, which suggests that there is great potential for improvement in this regard, as it is pointed out in the Food Sector Plan—Strategic Plan for the Valencian Industry.

- Distribution

Another key element in the agri-food sector is food distribution, which consists of connecting the productive and industrial sectors with consumers through the marketing of food products.

In Spain, food distribution is a vital component of the economy, ranging from small shops to large distribution chains (Retail), and the hotel, restaurant and catering sector (Horeca). However, it is the large distribution chains where the greatest impact on the economy is observed, as they make up around 26.7% of the total number of companies dedicated to trade in Spain, providing employment for approximately 340,000 people and representing more than 50% of the total expenditure of Spanish households.

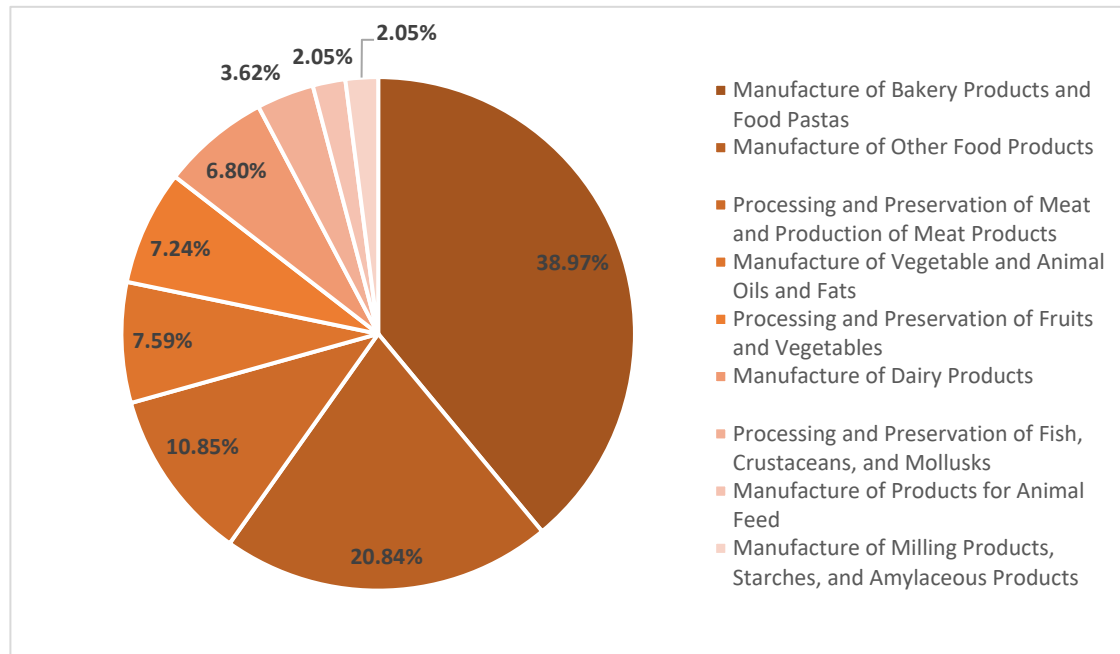


Figure 3. Relevance of the subsectors of the food/beverage sector in terms of number of companies at regional level (Valencian Community-Spain). Source: Elaborated from data from the DIRCE (Central Directory of Companies).

Like other components of the agri-food system, food distribution faces its own set of challenges, which are largely shaped by consumer preferences and behaviours. Retailers must respond to evolving consumption patterns, including a growing demand for products that align with nutritional, health, and environmental standards. Additionally, the recent increase in online shopping has reshaped market dynamics, prompting stakeholders to adapt by expanding digital retail channels. A fundamental consideration when introducing circular economy strategies in the agri-food sector is the identification of the main food distribution channels. Understanding the structure and evolution of food distribution is therefore essential for designing effective circular economy strategies that are aligned with both market trends and sustainability objectives (Figure 4). According to data presented in the *Report on food consumption in Spain in 2022*, published by the Ministry of Agriculture, Fisheries and Food [50], supermarkets and self-service stores are the preferred source of food and beverages for household purchases, accounting for 49.5% of the food volume. This highlights their strategic relevance in the agri-food supply chain, suggesting that circular interventions such as the reduction in non-reusable packaging, improved waste management, or surplus redistribution could generate significant impact in advancing towards a more sustainable distribution channel. Moreover, traditional markets continue to play a significant role in the distribution of fresh food, accounting for 30.2% of the channel. This demonstrates the importance of incorporating small-scale retail into circular economy strategies, particularly with respect to reducing post-harvest losses, improving the management of organic waste, and promoting the use of returnable or compostable packaging solutions. Regarding e-commerce, despite its growth in recent years, this channel

still represents a relatively low share of food distribution (1.2% for fresh products and 3.0% for other food items). Nevertheless, digital commerce offers promising opportunities for the implementation of circular models based on reverse logistics, reusable packaging systems, and waste reduction through demand forecasting.

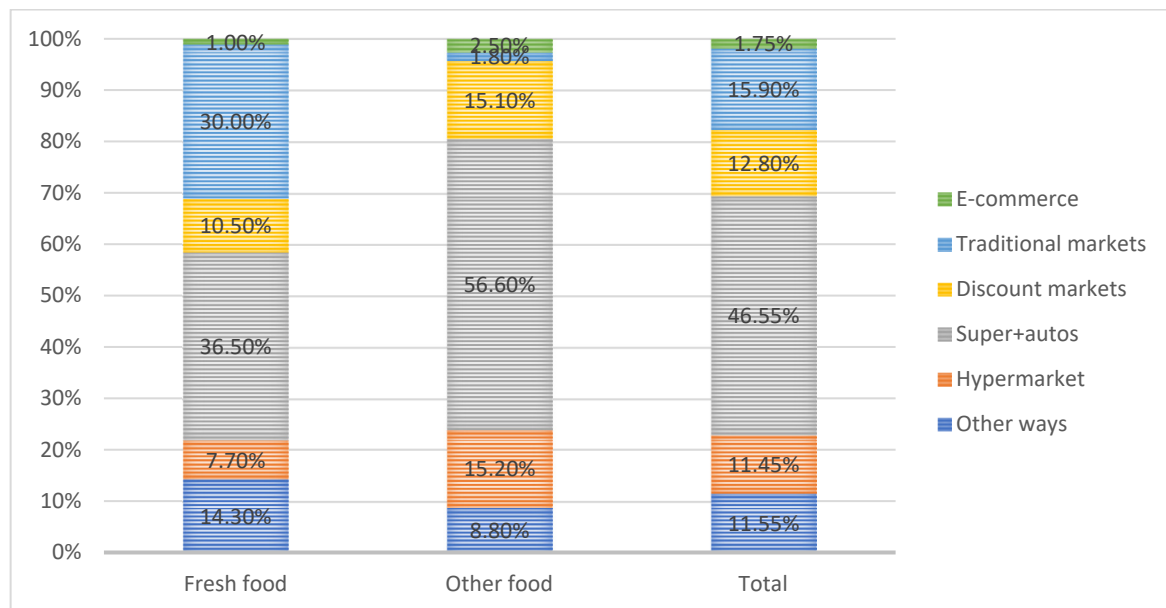


Figure 4. Relevance of food distribution channels by type of food in Spain. Source: own elaboration based on data obtained from the Spanish Ministry of Agriculture, Fisheries and Food [50].

- Consumption

The last step in the food chain corresponds to consumers, who are becoming increasingly important due to new trends in responsible consumption.

According to the data presented in the Report on food consumption in Spain in 2022, prepared by the Ministry of Agriculture, Fisheries and Food [50], Spanish people consumed around 26,987.66 million kilos or litres of food and beverages in 2022 in households, which means an approximate intake of 583.48 kilos or litres per person per year (see red box in Figure 5). This has led to a total expenditure of 73,893.40 million euros, which represents an average expenditure per person of around €1597.58 (see red box in Figure 5). If we add consumption inside and outside the home, a total of 30,946.87 million kilos or litres of food and drink were purchased in Spain in 2022, with a value of 107,780.51 million euros, which translates into a per capita consumption of 698.50 kilos or litres, representing an average total expenditure of approximately 2582.09 euros per person per year (Figure 5).

A comparative analysis of these data with those of the previous year shows that the total amount of food purchased by Spanish people is 7.1% lower than in the previous year; however, in economic terms, total expenditure on food and beverages has increased by 2.7%. This increase in spending is not only due to a higher consumption of food and drink outside the home, which has a higher added value, but also to the increase in the price of food and drink.

With regard to the type of food, an overall reduction in consumption of all product types has been observed over the course of 2022, especially in fresh foods such as fresh fruit, vegetables and potatoes, as well as meat and fish. However, the percentages of consumption per food type remain constant compared to previous years, with fresh food accounting for 37.3% of the total food volume, and non-fresh food accounting for the other 62.7% of the volume.

Consumers are increasingly guided by criteria such as sustainability, health and corporate image. According to the study conducted by Observatorio Cetelem Consumo European 2017, there is a greater willingness to pay for trusted products compared to others that are not, and a large proportion of Spanish consumers follow the recommendations and opinions that other users leave on the internet when making their purchases [43].

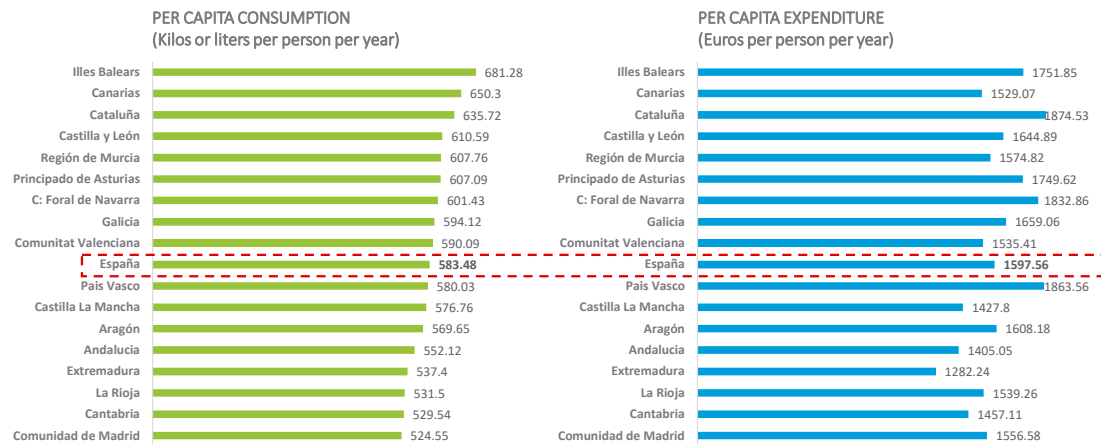


Figure 5. Food consumption and food expenditure per capita in Spain. Source: own elaboration based on data obtained from Spanish Ministry of Agriculture, Fisheries and Food [50].

4. Designing Circular Strategies: Insights from a SWOT Assessment

4.1. Methodological Approach and Practical Application of SWOT Analysis

To identify the strategic priorities for advancing circular economy practices within the agri-food sector, a comprehensive SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis has been conducted. The SWOT analysis is one of the most famous and valuable strategic planning tools worldwide [51,52], since it provides a holistic understanding of a company or institution's position in its environment. It consists of a practical method that allows to carry out logical and organised reasoning of the internal and external, both positive and negative, factors that affect or may affect a business, entity or territory (Figure 6). Although the origins of this method date back to the 1950s [53], the usefulness of this methodology has prevailed up to the present day [51,53,54].



Figure 6. Visual representation of the SWOT analysis and question that should be made to guarantee an appropriate application. Own elaboration.

Next, Table 2 outlines the main findings of the SWOT analysis carried out for the agri-food sector with the aim of guiding the formulation of several strategies to shift towards a more sustainable sector.

Table 2. Application of the SWOT analysis to implement circular economy strategies in the agri-food sector.

Strengths	Weaknesses
- Potential minimisation of waste streams: GHG emissions, plastic packages, food loss [12,55–58]. - Valuable by-products that could be reused, recycled or valorised [59,60]. - Great capability to optimise the use of resources [61]. - Easy to create synergies among different actors [62,63].	- Stuck in traditional practices/technological and innovative immaturity [64]. - Difficulties of the actors to invest in innovation and technologies [64]. - Lack of awareness of the benefits that some circular economy strategies could provide [64]. - Complexity of the sector [65].
Opportunities	Threats
- Existence of policies concerned about the environmental impacts of the sector [66–68]. - Agri-food chain is a strategic sector [23,69,70]. - New business and market opportunities [62,63,71].	- Climate change effects [64,72,73]. - Water crisis [74,75]. - Great dependency on public subsidies [76]. - Rural exodus and ageing of the population engaged in agriculture [77].

4.2. Translating SWOT Results into Circular Economy Strategies

By aligning internal strengths with external opportunities, and addressing weaknesses and threats through targeted actions, context-specific interventions can be set. This approach is grounded in the logical integration of SWOT analysis elements, guided by four key strategic alignment questions that facilitate a comprehensive and solution-oriented planning process [78]:

- SO (Strength–Opportunity) Combinations: Which strengths can be leveraged to take advantage of opportunities?
- TW (Threat–Weakness) Combinations: Which weaknesses, when paired with threats, highlight the need for policy or institutional intervention?
- TS (Threat–Strength) Combinations: Which strengths can help mitigate specific threats?
- WO (Weakness–Opportunity) Combinations: Which opportunities can be used to overcome internal weaknesses?

Based on this procedure and considering the specific characteristics and challenges of the agri-food sector, the experts consulted in this study identified the following circular economic strategies as having the greatest potential impact on the sector (Table 3):

Table 3. Circular Strategies for the Spanish Agri-Food Sector based on the SWOT analysis developed.

Target	Circular Strategy	Improved Description	Applied SWOT Combination
Improving the efficiency of the production system	1. Implementation of Green Technology and Innovation	Promote the transition to clean technologies, process digitalization, artificial intelligence, and precision agriculture to improve resource efficiency and traceability.	WO: Tackles the lack of innovation and technological maturity by leveraging environmental policies and the sector's strategic relevance.
	2. Building Knowledge and Awareness	Implement training programmes and promote best circular practices for farmers, processors, and distributors. Strengthen awareness of the economic and environmental benefits of circularity.	WO: Addresses the lack of awareness and sector complexity by taking advantage of institutional frameworks and market opportunities.

Table 3. Cont.

Target	Circular Strategy	Improved Description	Applied SWOT Combination
Improving the efficiency of the production system	3. Resilience Strategies Against Global Risks	Develop adaptive, diversified, and resilient production systems that reduce vulnerability to external shocks (climatic, economic, demographic).	WT: Addresses threats such as climate change, water crisis, and subsidy dependence by mitigating vulnerabilities in current production systems.
	4. Revitalization of the industry	Stimulate circular entrepreneurship in rural areas through incentives, green cooperatives, bioeconomy, and regenerative agri-food models.	WT: Addresses rural exodus and subsidy dependency by generating new local circular opportunities.
Reducing the consumption of resources	5. Minimising the Dependency on Chemical Products	Reduce reliance on conventional fertilisers and pesticides by promoting biofertilizers, biological control methods, and agroecological practices.	ST: Minimises emissions and waste by leveraging subproducts and inter-sectoral synergies.
	6. Optimising Water Resources	Promote efficient water use through smart irrigation technologies, water reuse systems, and drought-tolerant crops.	ST: Uses the sector's resource optimisation capacity to counter threats like climate change and water scarcity.
Minimising the generation of waste	7. Mitigating Greenhouse Gas Footprint	Promote energy efficiency and renewable energy adoption across the entire agri-food chain. Replace fossil fuels, improve logistics, and encourage carbon footprint certification schemes.	SO/ST: Building on the strength of potential minimisation of GHG emissions this strategy responds to threats posed by climate change and aligns with national and EU climate goals.
	8. Minimising Food Loss and Waste	Develop integrated systems for collecting, redistributing, processing, and valorising food surpluses for human, animal, or energy use.	SO: Uses the waste minimization potential and subproducts to create circular business models.
	9. Limiting Non-Reusable Plastic Packaging Consumption	Promote reusable, biodegradable, or compostable packaging through incentives and regulations that accelerate the sector's transition.	SO/ST: Reduces the waste footprint with circular solutions in the face of regulatory and environmental threats.
	10. Territorial Synergies and Cross-Industry Collaboration (Industrial Symbiosis)	Promote connections between sectors (e.g., livestock, food, energy, biofertilizers) where waste from one industry serves as input for another.	SO: Leverages the potential for synergies and valorised subproducts to foster new cooperative models.

4.2.1. Improving the Efficiency of the Production System

- Implementation of Green Technology and Innovation

One of the main weaknesses found in the sector is the lack of innovation and advanced technology that facilitates work, improving the efficiency of productive activity while being more respectful with the environment. For example, the use of drones or the installation of sensors can help to detect or predict the water requirements of crops or even prevent the presence of plagues before they infect plants or animals, thus reducing the amount of resources to be used, such as water, pesticides or antibiotics, and offering healthier and more sustainable products. Therefore, to promote technological development and innovation in activities it is necessary to invest in R + D + i.

Another aspect that is worth highlighting is the need for investment in technologies to improve energy efficiency in agricultural machinery, irrigation, farms and fishing fleets. This will require, above all, helping small producers to acquire such technologies.

Besides promoting the use of more efficient technologies that assist practical tasks, there are also other tools such as digitalisation that could turn into a great ally for the implementation of the circular economy, thanks to their capacity to generate, analyse and

share information between different actors, thus helping to optimise the management of the resources used, the waste generated and the products created [79]. In this same direction, the introduction of disruptive technologies [23,80], such as big data, artificial intelligence or the internet of things, which help to predict and automatize processes and even the organisation, improving its efficiency, can also be very useful. This type of new and innovative technology has great potential to be applied throughout the entire agri-food chain.

- **Building Knowledge and Awareness**

In order to introduce technology and innovation in the sector, it is necessary to raise awareness of the necessity and applicability of the measures or techniques that are being implemented; therefore, training and awareness-raising of all stakeholders involved in the production sector is a fundamental tool to ensure a more efficient sector. In this regard, it is essential to provide access to lifelong learning opportunities and to provide incentives for those who continue training.

However, where the greatest effort is required in this respect is again in the productive sector, where traditional agricultural, livestock and fishing practices are still deeply rooted, in many cases due to a lack of knowledge or distrust of more innovative and efficient practices. To overcome this barrier, the creation of training programmes on sustainability, ecological or digital agriculture/livestock/fishing, sustainable agricultural/livestock/fishing practices, innovation linked to the Sustainable Development Goals (SDGs), the circular economy, climate change, etc., can be extremely useful, raising awareness and promoting the most sustainable practices capable of protecting the environment through a more efficient management of natural resources and waste, and improving the well-being of rural communities, guaranteeing the future demand for food under sustainable principles.

Some specific areas where training and awareness-raising can be of great help in order to protect the environment and marine and terrestrial ecosystems are presented below. Concerning the agriculture sector, training on organic and sustainable agriculture, with an emphasis on maintaining soil fertility and productivity, through crop rotation programmes, using high-yielding seeds or using organic nutrients, is essential. Within the fishing sector, training in sustainable practices in terms of fisheries is useful to avoid practices that put at risk vulnerable marine species and resources along the whole supply chain, as well as not trading with endangered species or contracting with suppliers that promote illegal fishing.

- **Resilience Strategies Against Global Risks**

As is well known, climate change has become one of the primary concerns of our global society due to its impacts on the environment and people. In recent years, the effects of climate change have been particularly notable in the Mediterranean region, where extreme temperatures have been recorded, precipitation has significantly decreased, and the average sea water temperature has increased by approximately 2 °C compared to the reference period of 1982–2015.

These alterations have very significant negative impacts on the agricultural sector, as the decrease in precipitation, coupled with rising temperatures, hinders the fulfilment of water needs to meet crop water demand. Moreover, the increase in temperatures itself disrupts the life cycle of crops and pollinating organisms. Additionally, this temperature rise also escalates the risk of crop infestations due to a higher incidence of plant pests and diseases. According to [81,82], the effects of climate change disturb the nutrient balance in the soil. Other authors point out that climate change has increased the frequency and severity of wildfires, jeopardising existing crop fields.

All the aforementioned aspects disrupt agricultural production, thereby posing a risk to the agri-food sector and the nutritional demands of society. Therefore, it is imperative to

urgently introduce mitigation measures to ensure the economic balance of the agri-food sector and guarantee the fulfilment of global food demand. Integrated mitigation plans must be designed at the local, regional, and national levels to respond to and alleviate the negative effects that climate change may generate on crops and livestock due to natural disasters or environmental impacts. Likewise, the training of agricultural workers is fundamental and necessary to familiarise them with and implement practices that offer greater resilience to these factors, ensuring sustainable agricultural production.

- Revitalization of the industry

The innovation in the sector stems not only from technology but also from generational renewal. One of the primary characteristics of the agricultural sector is the involvement of elderly individuals, it is estimated that only 14% of the farmers in the European Union are less than 40 years [83], coupled with the abandonment of agricultural practices due to the rural exodus that has occurred in recent years [77]. In order to prevent rural depopulation and ensure the continuity of the primary sector, it is necessary to encourage and promote life in rural areas through campaigns, such as those already undertaken, as well as the recruitment and training of young people or individuals in vulnerable situations in the local communities where companies engaged in the agri-food sector are operating.

4.2.2. Reducing the Consumption of Resources

- Minimising the Dependency on Chemical Products

The reduction in chemicals in agriculture is an increasingly important issue in the context of sustainability and environmental preservation. Traditional agriculture has often relied heavily on the use of chemical pesticides and fertilisers to increase productivity and protect crops from pests and diseases, overlooking the problems these substances create for human health, biodiversity, soil and water quality [5–7]. The use of sustainable agricultural technology and practices such as crop rotation, composting or biological control become alternative methods to the use of chemicals, without reducing or even increasing crop productivity. However, the path towards a greener and more balanced agriculture requires a continued commitment from farmers, scientists, governments and consumers to foster innovation and ensure long-term food security.

- Optimising Water Resources

We are currently facing an unprecedented water crisis, arising as a result of the excessive use of water resources to meet the demand for drinking water or to support agricultural, livestock and industrial production. The overexploitation of water resources together with the pollution of water bodies has significantly reduced the availability of the resource, both in quantity and quality, a situation that has been exacerbated by the effects of climate change. Water scarcity has become a challenge not only at the local or regional level, but also at the global level, requiring the implementation of urgent measures for more efficient and sustainable water management.

The agricultural sector has been and is still the main consumer of water; therefore, this situation puts its continuity and economic development, and consequently that of the agri-food sector as a whole, at risk [74]. Therefore, it is necessary to implement measures to ensure sustainable water management by investing in technologies that improve the short and long-term efficient use of water through a strict policy of consumption and reuse. It is also advisable to promote the use of technologies that minimise water use in agriculture, based on drop irrigation systems or systems that monitor the water requirements of crops in order to optimise the use of water while maximising the production. The use of non-conventional resources such as reclaimed water is presented as an opportunity to meet

water demands without reducing the economic growth and development but minimising the pressure on water bodies.

However, the implementation of a more efficient and sustainable management should not only be applied in the agricultural sector, but it must be broadened to the whole chain. There are industrial processes related to the food processing that require the use of great volumes of water [84], for which reason the implementation of measures to promote water saving and recovery in the processing of food products is essential to guarantee the sustainability of water resources and of the agri-food sector as a whole.

4.2.3. Minimising the Generation of Waste

- Mitigating Greenhouse Gas Footprint

Changes in the agricultural production system throughout the 20th century resulting from the mechanisation of agricultural practices and greater industrialisation in the post-production stages have made the agri-food sector a high energy consumer, most of which comes from non-renewable sources [85]. Agriculture is considered to be mainly responsible for direct greenhouse gas emissions as a consequence of the use of traction machines, and indirectly for pumping water in irrigation systems or the manufacture of fertilisers, pesticides and greenhouse materials. It is estimated that the agri-food sector, and specifically agriculture, is responsible for the 18% of the diffuse emissions generated in Spain, which our country is committed to decrease by 26% until 2030 in the Paris Agreement ratified at the beginning of [43]. This highlights the need to implement strategies to mitigate the generation of greenhouse gases. However, as [85] point out, it is necessary to extend these measures to all activities in the agri-food sector, as it has been observed that in recent years energy consumption has escalated in the rest of the agri-food chain as a result of a change in our diet towards more processed food (Figure 7).

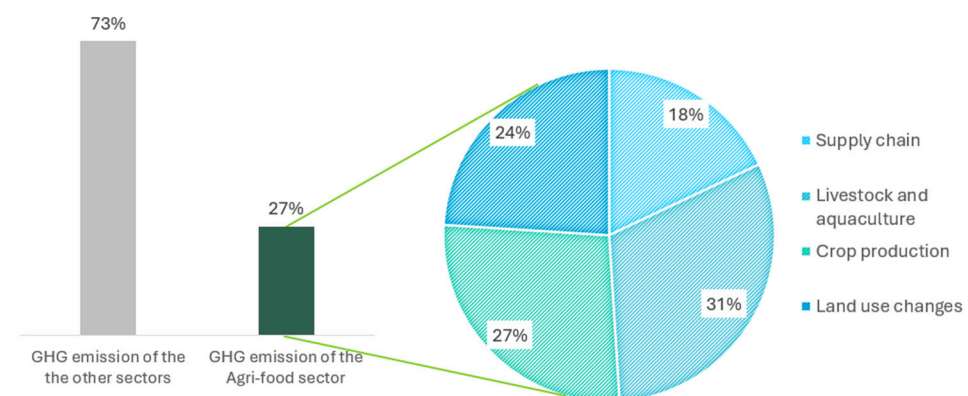


Figure 7. Greenhouse gas emissions from the agri-food sector. Source: Adapted from [85].

In order to reduce GHG emissions, it is crucial to reduce the use of fossil fuels in all operations and activities involved in the agri-food sector, replacing the electromechanical equipment involved in the processes with less energy-intensive and more efficient equipment and, if possible, replacing the energy supply through fossil energy sources with renewable sources of energy. Another key aspect is the improvement of product logistics management, for example, digitalisation can be very useful in optimising transport routes, thus reducing CO₂ emissions. Nevertheless, to ensure the effective implementation of these practices, it is essential to train and raise awareness among all stakeholders, and to develop strategies that establish clear short- and long-term objectives to reduce CO₂ emissions and combat climate change, as well as to implement certification systems that encourage companies to apply more sustainable practices in terms of greenhouse gas emissions.

- Minimising Food Loss and Waste

According to the data presented in [43], an estimated 40% to 60% of the food produced is wasted. Approximately half of this percentage is lost before food products reach final consumers, a situation that could be mitigated through improvements in the efficiency of conservation and transportation systems. Additionally, addressing food waste in direct consumption is crucial, requiring awareness campaigns to promote responsible purchasing by consumers.

However, the food service sector also significantly contributes to food waste, where a substantial amount of food goes unconsumed and is ultimately discarded [86]. Reducing this waste involves not only better management of food quantities but also the implementation of efficient conservation systems that enable the utilisation of foods or products not served [87]. This approach not only benefits the environment by reducing waste generation but also contributes to economic efficiency by maximising the utilisation of available food resources.

Raising awareness and adopting sustainable practices at all levels of the food chain are essential to address this challenge and work towards a more efficient and sustainable food system [88]. The collaboration of stakeholders, including producers, distributors, retailers, and consumers, is key to implementing effective strategies that can result in a significant reduction in food waste, promoting a more responsible and sustainable approach to food consumption and production.

- Limiting Non-Reusable Plastic Packaging Consumption

The imperative of sustainable packaging management, particularly in the case of plastic, underlines the urgent need for transformative action. With over 95% of the economic value of plastic packaging lost and only 15% recovered for recycling [89], there is a significant opportunity to notably increase the amount of material recycled. However, achieving this will require not only a significant change in consumer behaviour, but also the implementation of innovative technological processes to recover the material currently lost to landfill [90].

A key strategy for achieving sustainability is to reduce and optimise the use of plastics in packaging, while promoting and substituting plastics with more environmentally friendly materials [91]. The use of biodegradable materials and the promotion of cooperation within the value chain to encourage reuse and recycling are integral aspects of this strategy. The choice of sustainable materials not only reduces the environmental footprint of products but also plays an important role in encouraging more responsible practices within the sector. However, for this approach to be effective, it is essential that an appropriate management system and infrastructure is developed at the same time and that consumers are clearly informed about the use and ultimate disposal of these materials.

The transition to sustainable packaging management requires a multi-faceted approach that includes changes in consumer behaviour, technological innovation and a comprehensive shift towards environmentally friendly materials [92]. This holistic strategy not only addresses the current challenges of economic and environmental loss but also sets the stage for a more responsible and sustainable future for the packaging industry.

- Territorial Synergies and Cross-Industry Collaboration (Industrial Symbiosis)

Industrial symbiosis can become the perfect ally for the transformation of the current agri-food sector into a more sustainable and circular economic system. Industrial symbiosis is presented as a model of industrial ecology, where the fundamental aspect is the collaboration and productive synergy that can exist between different economic or industrial activities as a result of the exchange and sharing of resources [93]. Through this collaboration, resources are exchanged, which in some cases are the waste or by-products of one industry or industrial process becoming raw material for another. The application of

this concept allows materials to be used more sustainably and contributes to the creation of a circular economy.

Promoting the generation of energy from food waste that is no longer fit for consumption is an effective strategy to produce electricity and biogas without causing damage to the environment. This innovative approach not only reduces food waste, but also contributes to the generation of more sustainable energy sources. In addition, building partnerships between companies in the agri-food sector emerges as a key pillar to enhance sustainable innovation throughout the value chain. Collaboration between these actors enables the exchange of knowledge, resources and technologies, promoting more responsible and efficient practices in food production and distribution. In the field of logistics, collaboration between all companies in the agri-food chain is an opportunity to improve transport and distribution services for goods. Optimising available routes and loads not only reduces costs, but also contributes significantly to sustainability by reducing the environmental footprint associated with the transport of products. Furthermore, public-private partnerships are a powerful strategy to realise projects that contribute to achieving the principles of the circular economy. Figure 8 offers an example of how industrial symbiosis could be implemented in the agri-food sector.

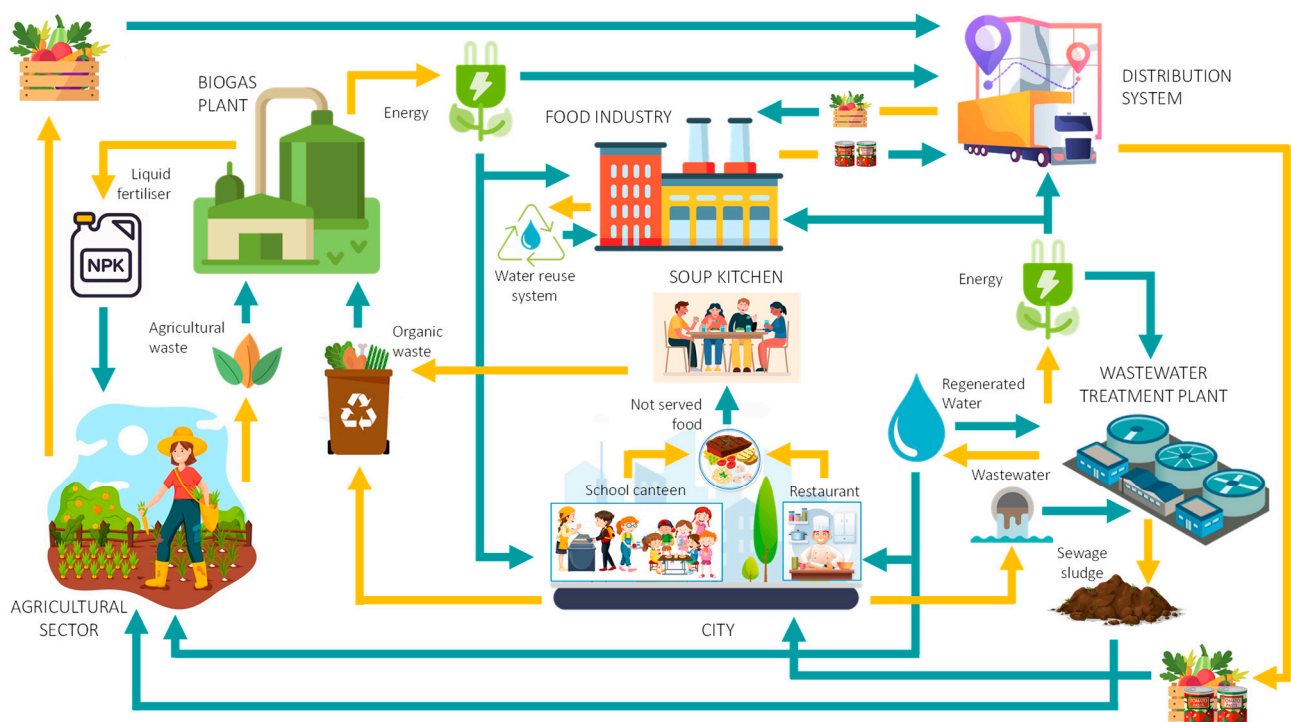


Figure 8. Example of industrial symbiosis in the agri-food sector (yellow arrows represent waste generated, and blue arrows represent the resources). Source: own elaboration.

It can be said that industrial symbiosis falls under the paradigm of the circular economy, understanding it as a strategy or tool that acts fundamentally on the industrial and productive sector, transforming it into a more sustainable productive system. In short, the active participation of civil society, the public sector, the academic world and other companies in these alliances guarantees an integral perspective and the achievement of objectives that promote social and environmental well-being.

5. Research Gaps and Emerging Challenges

Achieving a sustainable agri-food system that fully aligns with European objectives requires more than simply identifying strategic areas of action; it necessitates a thorough

examination and careful design of targeted financing mechanisms capable of ensuring the feasibility of essential investments.

Investment in technological innovation is particularly critical to modernising production processes, optimising resource use, and enhancing the valorisation of by-products. Nevertheless, such efforts entail substantial costs that are often difficult for enterprises, especially for small and medium-sized ones, to assume without access to adequate financial instruments. In this regard, it becomes crucial to evaluate a range of alternatives, including European funds, national subsidies, concessional credit lines, and tax incentives, which may help reduce financial barriers to innovation.

Equally important is the creation of collaborative networks capable of generating synergies both within the agri-food sector and across other industries through industrial symbiosis. These networks have the potential to optimise resource flows and contribute to the zero-waste target, but they also require financial resources to support shared infrastructures, information-exchange platforms, and pilot initiatives.

Accordingly, greater emphasis should be placed on the detailed exploration of diverse financing frameworks that combine public and private instruments at both national and international levels, with the objective of providing flexible solutions adapted to the specific characteristics and needs of each subsector. Only through a comprehensive and well-founded financial approach will it be possible to ensure that investments in technology, industrial symbiosis networks, and zero-waste platforms generate sustainable and long-lasting outcomes.

6. Conclusions

The agri-food sector is not only a crucial supplier of food globally, but also has a significant influence on the economy, employment and cultural identity, being a fundamental pillar in the sustainability and integral development of communities. As it has been demonstrated throughout the study with the Spanish figures, the agri-food sector is fundamental to the country's economy, providing employment and contributing significantly to the GDP, but at the international level it is a key player in the production and export of food. The continuous expansion and development of these subsectors contribute significantly to the national and international economic panorama, consolidating Spain as a reference in the agri-food industry. However, as it has been shown, in order to continue with the development and guarantee the economic, environmental and social balance of the sector, it is necessary to implement a range of measures to make it more sustainable in the long term.

To achieve this objective, a series of measures based on the basic principles of the circular economy are proposed, the aim of which is to promote strategies based on the reduction, reuse, recycling and recovery of products throughout all stages of the production, distribution and consumption cycle, remaining in the economic system for as long as possible, contributing to the preservation of natural resources, minimising the environmental impact and promoting the resilience of the sector in the face of future challenges. The effective implementation of these practices not only brings benefits to producers, but also aligns with the growing expectations of consumers in terms of sustainability and environmental responsibility.

Therefore, the circular economy stands as a key component in safeguarding the health of the planet and improving people's quality of life in a sustainable way. By promoting responsible practices and efficient resource management, this model contributes to building a more equitable and resilient society committed to preserving the natural environment for present and future generations. Its successful implementation requires the active collaboration of governments, businesses and citizens, establishing a comprehensive framework that drives the widespread adoption of circular practices.

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References

1. Oberle, B.; Bringezu, S.; Hatfield-Dodds, S.; Hellweg, S.; Schandl, H.; Clement, J. *Global Resources Outlook: 2019*; International Resource Panel; United Nations Enviro: Paris, France, 2019.
2. Allan, J.; Ojeda-García, R. Natural resource exploitation in Western Sahara: New research directions. *J. N. Afr. Stud.* **2022**, *27*, 1107–1136. [CrossRef]
3. Puntillo, P.; Gulluscio, C.; Huisingh, D.; Veltri, S. Reevaluating waste as a resource under a circular economy approach from a system perspective: Findings from a case study. *Bus. Strategy Environ.* **2021**, *30*, 968–984. [CrossRef]
4. Lieder, M.; Rashid, A. Towards circular economy implementation: A comprehensive review in context of manufacturing industry. *J. Clean. Prod.* **2016**, *115*, 36–51. [CrossRef]
5. Athukorala, W.; Lee, B.L.; Wilson, C.; Fujii, H.; Managi, S. Measuring the impact of pesticide exposure on farmers' health and farm productivity. *Econ. Anal. Policy* **2023**, *77*, 851–862. Available online: <https://www.sciencedirect.com/science/article/pii/S0313592622002156> (accessed on 23 September 2025). [CrossRef]
6. Mahmood, I.; Imadi, S.R.; Shazadi, K.; Gul, A.; Hakeem, K.R. Effects of pesticides on environment. In *Plant, Soil and Microbes: Implications in Crop Science*; Springer: Berlin/Heidelberg, Germany, 2016; Volume 1, pp. 253–269.
7. Zhou, W.; Li, M.; Achal, V. A comprehensive review on environmental and human health impacts of chemical pesticide usage. *Emerg. Contam.* **2025**, *11*, 100410. Available online: <https://www.sciencedirect.com/science/article/pii/S2405665024001112> (accessed on 23 September 2025). [CrossRef]
8. Castillo-Díaz, F.J.; Belmonte-Ureña, L.J.; López-Serrano, M.J.; Camacho-Ferre, F. Assessment of the sustainability of the European agri-food sector in the context of the circular economy. *Sustain. Prod. Consum.* **2023**, *40*, 398–411. [CrossRef]
9. Duque-Acevedo, M.; Belmonte-Ureña, L.J.; Plaza-Úbeda, J.A.; Camacho-Ferre, F. The management of agricultural waste biomass in the framework of circular economy and bioeconomy: An opportunity for greenhouse agriculture in Southeast Spain. *Agronomy* **2020**, *10*, 489. [CrossRef]
10. Agnusdei, G.P.; Coluccia, B.; Pacifico, A.M.; Miglietta, P.P. Towards circular economy in the agrifood sector: Water footprint assessment of food loss in the Italian fruit and vegetable supply chains. *Ecol. Ind.* **2022**, *137*, 108781. Available online: <https://www.sciencedirect.com/science/article/pii/S1470160X22002527> (accessed on 23 September 2025). [CrossRef]
11. Infante-Amate, J.; Aguilera, E.; de Molina, M.G. Energy transition in Agri-food systems. Structural change, drivers and policy implications (Spain, 1960–2010). *Energy Policy* **2018**, *122*, 570–579. Available online: <https://www.sciencedirect.com/science/article/pii/S0301421518305007> (accessed on 23 September 2025). [CrossRef]
12. Karwacka, M.; Ciurzyńska, A.; Lenart, A.; Janowicz, M. Sustainable development in the agri-food sector in terms of the carbon footprint: A Review. *Sustainability* **2020**, *12*, 6463. [CrossRef]
13. Notarnicola, B.; Tassielli, G.; Renzulli, P.A. Modeling the agri-food industry with life cycle assessment. In *Life Cycle Assessment Handbook: A Guide for Environmentally Sustainable Products*; John Wiley & Sons, Inc.: Hoboken, NJ, USA, 2012; pp. 159–183.
14. Pacchera, F.; Arcese, G.; Poponi, S.; Ruggieri, A. *Environmental Life Cycle Assessment of Typical Organic Carrot in Central Italy*; Associazione Rete Italiana LCA: Rome, Italy, 2022.
15. Zając, P.; Avdiushchenko, A. The impact of converting waste into resources on the regional economy, evidence from Poland. *Ecol. Model.* **2020**, *437*, 109299. Available online: <https://www.sciencedirect.com/science/article/pii/S0304380020303690> (accessed on 23 September 2025). [CrossRef]
16. Kirchherr, J.; Reike, D.; Hekkert, M. Conceptualizing the circular economy: An analysis of 114 definitions. *Resour. Conserv. Recycl.* **2017**, *127*, 221–232. Available online: <https://www.sciencedirect.com/science/article/pii/S0921344917302835> (accessed on 23 September 2025). [CrossRef]

17. Poponi, S.; Arcese, G.; Pacchera, F.; Martucci, O. Evaluating the transition to the circular economy in the agri-food sector: Selection of indicators. *Resour. Conserv. Recycl.* **2022**, *176*, 105916. Available online: <https://www.sciencedirect.com/science/article/pii/S0921344921005255> (accessed on 23 September 2025). [CrossRef]
18. Ellen MacArthur Foundation. *Delivering the Circular Economy: A Toolkit for Policymakers*; Ellen MacArthur Foundation: Cowes, UK, 2015.
19. Castellet-Viciano, L.; Bellver-Domingo, Á.; Hernández-Chover, V.; Hernández-Sancho, F. Challenges and Recommendations for a Green Circular Economy. In *Green Circular Economy: A New Paradigm for Sustainable Development*; Springer: Berlin/Heidelberg, Germany, 2023; pp. 283–304.
20. Hysa, E.; Kruja, A.; Rehman, N.U.; Laurenti, R. Circular economy innovation and environmental sustainability impact on economic growth: An integrated model for sustainable development. *Sustainability* **2020**, *12*, 4831. [CrossRef]
21. Murray, A.; Skene, K.; Haynes, K. The circular economy: An interdisciplinary exploration of the concept and application in a global context. *J. Bus. Ethics* **2017**, *140*, 369–380. [CrossRef]
22. Ghisellini, P.; Cialani, C.; Ulgiati, S. A review on circular economy: The expected transition to a balanced interplay of environmental and economic systems. *J. Clean. Prod.* **2016**, *114*, 11–32. Available online: <http://www.sciencedirect.com/science/article/pii/S0959652615012287> (accessed on 23 September 2025). [CrossRef]
23. Ministry of Agriculture, Fisheries and Food of Spain. *Digitisation Strategy for the Agri-Food and Forestry Sector and Rural Areas*; Ministry of Agriculture, Fisheries and Food of Spain: Madrid, Spain, 2019.
24. Pagotto, M.; Halog, A. Towards a circular economy in Australian agri-food industry: An application of input-output oriented approaches for analyzing resource efficiency and competitiveness potential. *J. Ind. Ecol.* **2016**, *20*, 1176–1186. [CrossRef]
25. Marques, C.; Güneş, S.; Vilela, A.; Gomes, R. Life-Cycle Assessment in Agri-Food Systems and the Wine Industry—A Circular Economy Perspective. *Foods* **2025**, *14*, 1553. [CrossRef]
26. Velasco-Muñoz, J.F.; Mendoza, J.M.F.; Aznar-Sánchez, J.A.; Gallego-Schmid, A. Circular economy implementation in the agricultural sector: Definition, strategies and indicators. *Resour. Conserv. Recycl.* **2021**, *170*, 105618. Available online: <https://www.sciencedirect.com/science/article/pii/S0921344921002275> (accessed on 23 September 2025). [CrossRef]
27. Esposito, B.; Sessa, M.R.; Sica, D.; Malandrino, O. Towards circular economy in the agri-food sector. *A systematic literature review. Sustainability* **2020**, *12*, 7401.
28. Del Borghi, A.; Strazza, C.; Magrassi, F.; Taramasso, A.C.; Gallo, M. Life Cycle Assessment for eco-design of product–package systems in the food industry—The case of legumes. *Sustain. Prod. Consum.* **2018**, *13*, 24–36. Available online: <https://www.sciencedirect.com/science/article/pii/S2352550917300520> (accessed on 23 September 2025). [CrossRef]
29. Borsato, E.; Giubilato, E.; Zabeo, A.; Lamastra, L.; Criscione, P.; Tarolli, P.; Marinello, F.; Pizzol, L. Comparison of Water-focused Life Cycle Assessment and Water Footprint Assessment: The case of an Italian wine. *Sci. Total Environ.* **2019**, *666*, 1220–1231. Available online: <https://www.sciencedirect.com/science/article/pii/S0048969719308393> (accessed on 23 September 2025). [CrossRef] [PubMed]
30. Lovarelli, D.; Bacenetti, J.; Guarino, M. A review on dairy cattle farming: Is precision livestock farming the compromise for an environmental, economic and social sustainable production? *J. Clean. Prod.* **2020**, *262*, 121409. Available online: <https://www.sciencedirect.com/science/article/pii/S0959652620314566> (accessed on 23 September 2025). [CrossRef]
31. Pellegrini, G.; Ingrao, C.; Camposeo, S.; Tricase, C.; Conto, F.; Huisingsh, D. Application of water footprint to olive growing systems in the Apulia region: A comparative assessment. *J. Clean. Prod.* **2016**, *112*, 2407–2418. [CrossRef]
32. Kucukvar, M.; Onat, N.C.; Abdella, G.M.; Tatari, O. Assessing regional and global environmental footprints and value added of the largest food producers in the world. *Resour. Conserv. Recycl.* **2019**, *144*, 187–197. Available online: <https://www.sciencedirect.com/science/article/pii/S0921344919300564> (accessed on 23 September 2025). [CrossRef]
33. European Commission. A European Strategy for Plastics in a Circular Economy. 2018. Available online: <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52018DC0028> (accessed on 23 September 2025).
34. Pinyol Alberich, J.; Pansera, M.; Hartley, S. Understanding the EU’s circular economy policies through futures of circularity. *J. Clean. Prod.* **2023**, *385*, 135723. Available online: <https://www.sciencedirect.com/science/article/pii/S0959652622052970> (accessed on 23 September 2025). [CrossRef]
35. Matthews, C.; Moran, F.; Jaiswal, A.K. A review on European Union’s strategy for plastics in a circular economy and its impact on food safety. *J. Clean. Prod.* **2021**, *283*, 125263. [CrossRef]
36. European Commission. Chemicals Strategy for Sustainability—Towards a Toxic-Free Environment. 2020. Available online: <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52020DC0667> (accessed on 23 September 2025).
37. European Commission. A New Circular Economy Action Plan: For a Cleaner and More Competitive Europe. 2020. Available online: <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52020DC0098> (accessed on 23 September 2025).
38. European Commission. The European Green Deal. 2019. Available online: <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52019DC0640> (accessed on 23 September 2025).

39. Apostu, S.A.; Gigauro, I.; Panait, M.; Martín-Cervantes, P.A. Is Europe on the way to sustainable development? Compatibility of green environment, economic growth, and circular economy issues. *Int. J. Environ. Res. Public Health* **2023**, *20*, 1078. [CrossRef] [PubMed]
40. Zarbà, C.; Chinnici, G.; La Via, G.; Bracco, S.; Pecorino, B.; D'Amico, M. Regulatory elements on the circular economy: Driving into the agri-food system. *Sustainability* **2021**, *13*, 8350. [CrossRef]
41. Pascual, J.A.; Morales, A.B.; Ayuso, L.M.; Segura, P.; Ros, M. Characterisation of sludge produced by the agri-food industry and recycling options for its agricultural uses in a typical Mediterranean area, the Segura River basin (Spain). *Waste Manag.* **2018**, *82*, 118–128. Available online: <https://www.sciencedirect.com/science/article/pii/S0956053X1830638X> (accessed on 23 September 2025). [CrossRef]
42. European Commission. *Improving Market Transparency in the Agricultural and Food Supply Chain*; European Commission: Brussels, Belgium, 2019.
43. Sector Agroalimentario. *ICEX Guía Sectorial en ODS*; Red Española del Pacto Mundial de Naciones Unidas: Madrid, Spain, 2018.
44. Marsden, T.; Moragues Faus, A.; Sonnino, R. Reproducing vulnerabilities in agri-food systems: Tracing the links between governance, financialization, and vulnerability in Europe post 2007–2008. *J. Agrar. Change* **2019**, *19*, 82–100. [CrossRef]
45. Zhao, G.; Liu, S.; Lopez, C. A Literature Review on Risk Sources and Resilience Factors in Agri-Food Supply Chains; Collaboration in a Data-Rich World. In Proceedings of the 18th IFIP WG 5.5 Working Conference on Virtual Enterprises, PRO-VE 2017, Vicenza, Italy, 18–20 September 2017; Springer: Berlin/Heidelberg, Germany, 2017; pp. 739–752.
46. Wahdat, A.Z.; Lusk, J.L. The Achilles heel of the US food industries: Exposure to labor and upstream industries in the supply chain. *Am. J. Agric. Econ.* **2023**, *105*, 624–643. [CrossRef]
47. Bourne, M.; Childs, J.; Philippidis, G.; Feijoo, M. Controlling greenhouse gas emissions in Spain: What are the costs for agricultural sectors? *Span. J. Agric. Res.* **2012**, *10*, 567–582. [CrossRef]
48. Lucindo, J.; Feijoo, M.; González-Álvarez, M.A. Assessing regional convergence of greenhouse gas emissions in Spain: Insights from economic activities. *J. Environ. Econ. Policy* **2023**, *13*, 383–403. [CrossRef]
49. Delgado-Viñas, C. Reconversion of Agri-Food Production Systems and Deagrarianization in Spain: The Case of Cantabria. *Land* **2023**, *12*, 1428. [CrossRef]
50. Spanish Ministry of Agriculture, Fisheries and Food. *Report on Food Consumption in Spain in 2022*; Ministry of Agriculture, Fisheries and Food: Madrid, Spain, 2022.
51. Phadernrod, B.; Crowder, R.M.; Wills, G.B. Importance-Performance Analysis based SWOT analysis. *Int. J. Inf. Manag.* **2019**, *44*, 194–203. Available online: <https://www.sciencedirect.com/science/article/pii/S0268401216301694> (accessed on 23 September 2025). [CrossRef]
52. Dyson, R.G. Strategic development and SWOT analysis at the University of Warwick. *Eur. J. Oper. Res.* **2004**, *152*, 631–640. Available online: <https://www.sciencedirect.com/science/article/pii/S0377221703000626> (accessed on 23 September 2025). [CrossRef]
53. Chermack, T.J.; Kasshanna, B.K. The Use and Misuse of SWOT Analysis and Implications for HRD Professionals. *Hum. Resour. Dev. Int.* **2007**, *10*, 383–399. [CrossRef]
54. Ghazinoory, S.; Abdi, M.; Azadegan-Mehr, M. SWOT methodology: A state-of-the-art review for the past, a framework for the future. *J. Bus. Econ. Manag.* **2011**, *12*, 24–48. [CrossRef]
55. Facchini, F.; Silvestri, B.; Digiesi, S.; Lucchese, A. Agri-food loss and waste management: Win-win strategies for edible discarded fruits and vegetables sustainable reuse. *Innov. Food Sci. Emerg. Technol.* **2023**, *83*, 103235. Available online: <https://www.sciencedirect.com/science/article/pii/S1466856422003204> (accessed on 23 September 2025). [CrossRef]
56. Ncube, L.K.; Ude, A.U.; Ogunmuyiwa, E.N.; Zulkifli, R.; Beas, I.N. An overview of plastic waste generation and management in food packaging industries. *Recycling* **2021**, *6*, 12. [CrossRef]
57. Arijeniwa, V.F.; Akinsemolu, A.A.; Chukwugozie, D.C.; Onawo, U.G.; Ochulor, C.E.; Nwauzoma, U.M.; Kawino, D.A.; Onyeaka, H. Closing the loop: A framework for tackling single-use plastic waste in the food and beverage industry through circular economy—A review. *J. Environ. Manag.* **2024**, *359*, 120816. Available online: <https://www.sciencedirect.com/science/article/pii/S0301479724008028> (accessed on 23 September 2025). [CrossRef]
58. Acampora, A.; Ruini, L.; Mattia, G.; Pratesi, C.A.; Lucchetti, M.C. Towards carbon neutrality in the agri-food sector: Drivers and barriers. *Resour. Conserv. Recycl.* **2023**, *189*, 106755. Available online: <https://www.sciencedirect.com/science/article/pii/S0921344922005870> (accessed on 23 September 2025). [CrossRef]
59. Ligarda-Samanez, C.A.; Huamán-Carrión, M.L.; Calsina-Ponce, W.C.; Cruz, G.D.I.; Calderón Huamaní, D.F.; Cabel-Moscoso, D.J.; Garcia-Espinoza, A.J.; Sucari-León, R.; Aroquipa-Durán, Y.; Muñoz-Saenz, J.C. Technological Innovations and Circular Economy in the Valorization of Agri-Food By-Products: Advances, Challenges and Perspectives. *Foods* **2025**, *14*, 1950. [CrossRef]
60. Ahmad, T.; Esposito, F.; Cirillo, T. Valorization of agro-food by-products: Advancing sustainability and sustainable development goals 2030 through functional compounds recovery. *Food Biosci.* **2024**, *62*, 105194. Available online: <https://www.sciencedirect.com/science/article/pii/S2212429224016249> (accessed on 23 September 2025). [CrossRef]

61. Aznar-Sánchez, J.A.; Piquer-Rodríguez, M.; Velasco-Muñoz, J.F.; Manzano-Agugliaro, F. Worldwide research trends on sustainable land use in agriculture. *Land Use Policy* **2019**, *87*, 104069. Available online: <https://www.sciencedirect.com/science/article/pii/S0264837719303345> (accessed on 23 September 2025). [CrossRef]
62. Rațu, R.N.; Veleșcu, I.D.; Stoica, F.; Usturoi, A.; Arsenoia, V.N.; Crivei, I.C.; Postolache, A.N.; Lipșa, F.D.; Filipov, F.; Florea, A.M. Application of agri-food by-products in the food industry. *Agriculture* **2023**, *13*, 1559. [CrossRef]
63. Areti, H.A.; Muleta, M.D.; Abo, L.D.; Hamda, A.S.; Adugna, A.A.; Edae, I.T.; Daba, B.J.; Gudeta, R.L. Innovative uses of agricultural by-products in the food and beverage sector: A review. *Food Chem. Adv.* **2024**, *5*, 100838. Available online: <https://www.sciencedirect.com/science/article/pii/S2772753X24002338> (accessed on 23 September 2025). [CrossRef]
64. Pedersen, S.M.; Erekalı, K.T.; Christensen, T.; Denver, S.; Gemtoui, M.; Fountas, S.; Isakhanyan, G.; Rosemarin, A.; Ekane, N.; Puggaard, L.; et al. Drivers and barriers to climate-smart agricultural practices and technologies adoption: Insights from stakeholders of five European food supply chains. *Smart Agric. Technol.* **2024**, *8*, 100478. Available online: <https://www.sciencedirect.com/science/article/pii/S2772375524000832> (accessed on 23 September 2025). [CrossRef]
65. Iakovou, E.; Bochtis, D.; Vlachos, D.; Aidonis, D. Sustainable agrifood supply chain management. In *Supply Chain Management for Sustainable Food Networks*; John Wiley & Sons Inc.: Hoboken, NJ, USA, 2015; pp. 1–39.
66. Castillo-Díaz, F.J.; Belmonte-Ureña, L.J.; Batlles-de-laFuente, A.; Camacho-Ferre, F. Impact of the new measures related to the circular economy on the management of agrochemical packaging in Spanish agriculture and the use of biodegradable plastics. *Environ. Sci. Eur.* **2022**, *34*, 94. [CrossRef]
67. Cifuentes-Faura, J. European Union policies and their role in combating climate change over the years. *Air Qual. Atmos. Health* **2022**, *15*, 1333–1340. [CrossRef]
68. Shoushtarian, F.; Negahban-Azar, M. Worldwide regulations and guidelines for agricultural water reuse: A critical review. *Water* **2020**, *12*, 971. [CrossRef]
69. Vargas-Canales, J.M. The Great Transformation of the Agri-Food Sector: A Transformation for Life and Well-Being. *Agronomy* **2024**, *14*, 2123. [CrossRef]
70. El Bilali, H.; Strassner, C.; Ben Hassen, T. Sustainable agri-food systems: Environment, economy, society, and policy. *Sustainability* **2021**, *13*, 6260. [CrossRef]
71. Dania, W.A.P.; Xing, K.; Amer, Y. Collaboration behavioural factors for sustainable agri-food supply chains: A systematic review. *J. Clean. Prod.* **2018**, *186*, 851–864. Available online: <https://www.sciencedirect.com/science/article/pii/S0959652618308151> (accessed on 23 September 2025). [CrossRef]
72. Wang, D.; Jenkins, K.; Forstenhäusler, N.; Lei, T.; Price, J.; Warren, R.; Jenkins, R.; Guan, D. Economic impacts of climate-induced crop yield changes: Evidence from agri-food industries in six countries. *Clim. Change* **2021**, *166*, 30. [CrossRef]
73. Georgopoulou, E.; Gakis, N.; Kapetanakis, D.; Voloudakis, D.; Markaki, M.; Sarafidis, Y.; Lalas, D.P.; Laliotis, G.P.; Akamati, K.; Bizelis, I. Climate Change Risks for the Mediterranean Agri-Food Sector: The Case of Greece. *Agriculture* **2024**, *14*, 770. [CrossRef]
74. Shaikh, M.A.; Hadjikakou, M.; Bryan, B.A. Shared responsibility for global water stress from agri-food production and consumption and opportunities for mitigation. *J. Clean. Prod.* **2022**, *379*, 134628. Available online: <https://www.sciencedirect.com/science/article/pii/S0959652622042007> (accessed on 23 September 2025). [CrossRef]
75. Sutcliffe, C.; Knox, J.; Hess, T. Managing irrigation under pressure: How supply chain demands and environmental objectives drive imbalance in agricultural resilience to water shortages. *Agric. Water Manag.* **2021**, *243*, 106484. Available online: <https://www.sciencedirect.com/science/article/pii/S0378377420307228> (accessed on 23 September 2025). [CrossRef]
76. Heyl, K.; Ekardt, F.; Sund, L.; Roos, P. Potentials and limitations of subsidies in sustainability governance: The example of agriculture. *Sustainability* **2022**, *14*, 15859. [CrossRef]
77. Llorent-Bedmar, V.; Cobano-Delgado Palma, V.C.; Navarro-Granados, M. The rural exodus of young people from empty Spain. Socio-educational aspects. *J. Rural. Stud.* **2021**, *82*, 303–314. Available online: <https://www.sciencedirect.com/science/article/pii/S0743016721000140> (accessed on 23 September 2025). [CrossRef]
78. Falcone, P.M.; Tani, A.; Tartiu, V.E.; Imbriani, C. Towards a sustainable forest-based bioeconomy in Italy: Findings from a SWOT analysis. *For. Policy Econ.* **2020**, *110*, 101910. Available online: <https://www.sciencedirect.com/science/article/pii/S1389934118303630> (accessed on 23 September 2025). [CrossRef]
79. Antikainen, M.; Uusitalo, T.; Kivikytö-Reponen, P. Digitalisation as an Enabler of Circular Economy. *Procedia CIRP* **2018**, *73*, 45–49. Available online: <https://www.sciencedirect.com/science/article/pii/S2212827118305432> (accessed on 23 September 2025). [CrossRef]
80. Pakseresht, A.; Yavari, A.; Kaliji, S.A.; Hakelius, K. The intersection of blockchain technology and circular economy in the agri-food sector¹¹This work was supported by the Swedish University of Agricultural Sciences, Sweden, by a scholarship from L Nannesson's foundation, grant number Dnr SLU.ua.2019.3.1.5-617. *Sustain. Prod. Consum.* **2023**, *35*, 260–274. Available online: <https://www.sciencedirect.com/science/article/pii/S2352550922002986> (accessed on 23 September 2025). [CrossRef]
81. Kumar, R.; Das, A.J. Climate change and its impact on land degradation: Imperative need to focus. *J. Climatol. Weather Forecast.* **2014**, *2*, 108. [CrossRef]

82. Brevik, E.C. The potential impact of climate change on soil properties and processes and corresponding influence on food security. *Agriculture* **2013**, *3*, 398–417. [CrossRef]
83. Rovný, P. The Analysis of Farm Population with Respect to Young Farmers in the European Union. *Procedia Soc. Behav. Sci.* **2016**, *220*, 391–398. Available online: <https://www.sciencedirect.com/science/article/pii/S1877042816306140> (accessed on 23 September 2025). [CrossRef]
84. Asgharnejad, H.; Khorshidi Nazloo, E.; Madani Larijani, M.; Hajinajaf, N.; Rashidi, H. Comprehensive review of water management and wastewater treatment in food processing industries in the framework of water-food-environment nexus. *Compr. Rev. Food Sci. Food Saf.* **2021**, *20*, 4779–4815. [CrossRef] [PubMed]
85. Aguilera, E.; Piñero, P.; Infante Amate, J.; González de Molina, M.; Lassaletta, L.; Sanz Cobeña, A. *Emisiones de Gases de Efecto Invernadero en el Sistema Agroalimentario y Huella de Carbono de la Alimentación en España*; Real Academia de Ingeniería: Madrid, Spain, 2020.
86. Kumm, M.; de Moel, H.; Porkka, M.; Siebert, S.; Varis, O.; Ward, P.J. Lost food, wasted resources: Global food supply chain losses and their impacts on freshwater, cropland, and fertiliser use. *Sci. Total Environ.* **2012**, *438*, 477–489. Available online: <https://www.sciencedirect.com/science/article/pii/S0048969712011862> (accessed on 23 September 2025). [CrossRef]
87. Onyeaka, H.; Tamasiga, P.; Nwauzoma, U.M.; Miri, T.; Juliet, U.C.; Nwaiwu, O.; Akinsemolu, A.A. Using artificial intelligence to tackle food waste and enhance the circular economy: Maximising resource efficiency and minimising environmental impact: A review. *Sustainability* **2023**, *15*, 10482. [CrossRef]
88. Urugo, M.M.; Teka, T.A.; Gemed, H.F.; Mersha, S.; Tessema, A.; Woldemariam, H.W.; Admassu, H. A comprehensive review of current approaches on food waste reduction strategies. *Compr. Rev. Food Sci. Food Saf.* **2024**, *23*, e70011. [CrossRef] [PubMed]
89. World Economic Forum; Ellen MacArthur Foundation; McKinsey & Company. *The New Plastics Economy Rethinking the Future of Plastics*; Ellen MacArthur Foundation: Cowes, UK, 2016; Volume 36.
90. Ragaert, K.; Delva, L.; Van Geem, K. Mechanical and chemical recycling of solid plastic waste. *Waste Manag.* **2017**, *69*, 24–58. Available online: <https://www.sciencedirect.com/science/article/pii/S0956053X17305354> (accessed on 23 September 2025). [CrossRef] [PubMed]
91. Asgher, M.; Qamar, S.A.; Bilal, M.; Iqbal, H.M.N. Bio-based active food packaging materials: Sustainable alternative to conventional petrochemical-based packaging materials. *Food Res. Int.* **2020**, *137*, 109625. Available online: <https://www.sciencedirect.com/science/article/pii/S0963996920306505> (accessed on 23 September 2025). [CrossRef]
92. Ada, E.; Kazancoglu, Y.; Gozacan-Chase, N.; Altin, O. Challenges for circular food packaging: Circular resources utilization. *Appl. Food Res.* **2023**, *3*, 100310. Available online: <https://www.sciencedirect.com/science/article/pii/S2772502223000495> (accessed on 23 September 2025). [CrossRef]
93. Nugroho, Y.A.; Asih, A.M.S.; Sopha, B.M. Development of urban-industrial symbiosis to support sustainability: Bibliometric analysis and systematic literature review. *Discov. Sustain.* **2025**, *6*, 196. [CrossRef]

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