Agri Food Sector

Subjects: Others

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Definition

given the complexity of the sector, each supply chain has some peculiarities that require suitable tools. For this reason, it is difficult to identify a common tool for the implementation of circular practices. However, the use of a shared assessment tool should enable comparison of circular performances and practices among the different stages and supply chains and involving all the actors of the AFS. This collaborative approach is required both vertically (among the stages of the supply chain) and horizontally (among the different supply chains) in order to catalyse the transition towards circular business models and to efficiently implement circular practices.

sustainability
circular economy
LCA
agro-food supply chain
food waste

Introduction

Over the last decade, the unsustainability of the current economic model, based on the so-called take-make-dispose paradigm, has emerged. In particular, the agro-food sector (AFS) has been severely affected by such problems as resource scarcity and food loss and waste generation along the supply chain. In addition, climate change and biodiversity loss have helped to define an imperative paradigm shift towards a circular economy. Recently, with the publication of Sustainable Development Goals (SDGs), the scientific research examining the adoption of circular economy (CE) models and tools has increased. In this context, the importance of shifting towards a circular economy has become urgent. In this paper, a systematic literature review (SLR) was performed to investigate the state-of-the-art research related to the adoption of circular economy models and tools along the agro-food supply chain. Furthermore, this review highlights that,Due to the complexity of the agri-food supply chain, it is almost utopian to define a unique circular economy model for the whole sector. In addition, it emerges that future researches should be concentrated on the integration of different stages of the supply chain with circular economy models and tools in order to create a closed-loop agri-food system.

1. Research on the Circular Economy Applied to the Agro-Food Sector: The State-of-the-Art Research

Table 4 shows the results derived from the coding activity of the 87 articles according to the analytical framework previously described.

Table 4. Analytical framework of Circular Economy applied in the agro-food sector (AFS).

A.	Country of Research	No.	%	B.	Research Methods	No.	%
A1	Europe/UK	27	80.00	B1	Case/Field study/Interviews	66	76.00
A2	North America	5	6.00	B2	Survey/Questionnaire/Other empirical	3	3.00
A3	South America	4	5.00	B3	Commentary/Normative/Policy	11	13.00
A4	Oceania	1	1.00	B4	Literature review	7	8.00
A5	Asia	5	6.00		Total	87	100
A6	Africa	2	2.00				
	Total	87	100				
C.	Scientific Field	No.	%	D.	Focus on Tools Implemented	No.	%
C1	Agricultural science	19	21.84	D1	LCA	33	37.93
C2	Biology/Chemistry	7	8.04	D2	S-LCA	3	3.45
C3	Environmental science	22	25.29	D3	E-LCA	2	2.30
C4	Economy/Management	34	39.08	D4	WFA	3	3.45
	Mixed fields	5	5.75	D5	Combined tools	14	16.10
	Total	87	100	D6	Others	15	17.24
				D7	None	17	19.54
					Total	87	100
E.	Focus on Type of SC	No.	%	F.	SC Stage	No.	%
E1	Agriculture	45	51.72	F1	Production	14	16.10
E2	Dairy	3	3.45	F2	Processing	25	28.73
E3	Livestock farming	11	12.65		Retail	1	1.15
E4	Fish breeding	5	5.75	F3	Consumption	4	4.60
E5	Various	23	26.43	F4	The whole SC	43	49.42
E6	Total	87	100	F5	Total	87	100

Table developed in accordance with the methodology used by Manes Rossi et al., 2020 [1] and Bisogno et al., 2018 [2]

1.1. Country of Research

The first category concerns the âCountry of Researchâ. It was determined based on the country where the research took place. For articles where this data is not available, the country of research is based on the authorsâ affiliation. It is clear that the greatest number of the articles are located in Europe and the UK, with an overall percentage of 80.45%, totalling 70 articles. This trend can be explained by the emphasis that the European Union has placed on the development and adoption of CE models in all sectors and the sustainable performance of food products and processes by a plethora of measures adopted. In particular, with the communication âTowards a circular economy: A zero waste program for Europeâ[3] and the communication âClosing the loopâAn EU action plan for the circular economyâ[4], a great deal of attention has been paid to CE issues in European countries. In addition, the catalysing actions promoted by The Ellen McArthur Foundation (e.g., âThe Circular Economy 100 (CE100) Networkâ, âCities and CE for Food âand âMake Fashion Circularâ) have stimulated European scholars in investigating the CE as âan industrial system that is restorative or regenerative by intention and designâ[5]. Among European countries, Italy has provided a wider number of contributions, i.e., covering 36.78% of the analysed papers. This is justified by Italyâs strategic positioning on the CE and due to the increasing regulatory focus (e.g., law 221, 28 December 2015; the document named âTowards a model of Circular economy for Italyâ and other legislative decrees) on these aspects. Although Asian countries, in particular China, are pioneers of the CE as a new model of sustainable development, only a limited contribution is detected from this country of research (5 articles, i.e., 6.00%). In particular, it seems that the recent regulatory policies (e.g., guidelines for eco-industrial parks, 11th and 12th five-year plans for National Economic and Social Development, âCircular Economy Promotion Lawâ) about the adoption of the CE involving Asian countries did not stimulate significant research on this topic. However, among Asian states, China has paid particular attention to CE issues from a regulatory point of view. In fact, Yuan et al.[6] have shown that it has been one of the foundation strategies of the country in the 21st century. North America (5 articles, i.e., 6.00%), South America (4 articles, i.e., 5.00%), Africa (2 articles, i.e., 2.00%) and Oceania (1 article, i.e., 1.00%) have contributed fewer works than the other regions, as is shown in Figure 4.

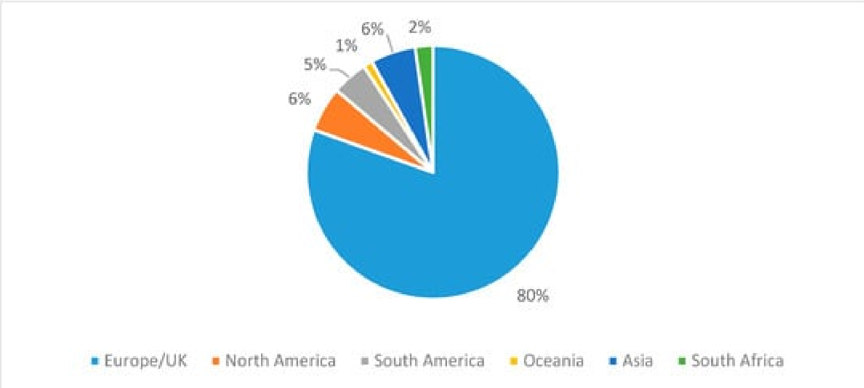

Figure 4. Distribution of literature published in the sample by country.

1.2. Research Methods

Concerning the category âResearch Methodsâ, Figure 5 shows the percentage of papers belonging to each sub-category with the aim of investigating the research methodologies adopted by scholars to evaluate the research trend in the journey from a linear economy approach to a CE one from a chain perspective[7]. In this context, it is a priority for researchers to determine the most suitable route for the creation of sustainable and efficient agro-food systems[8] Not surprisingly, case/field studies and interviews have been widely adopted to conduct an analysis of the individual SCs of the AFS (66 articles, i.e., 76.00%). In fact, most scientific contributions concerning CE are focused on the use of environmental, social and economic impact assessment tools. Instead, only three articles belong to âSurvey/Questionnaire/Other empiricalâ. Critically assessing these data, an increased trend towards empirical research rather than conceptual research is demonstrated. The theoretical categories, which are discussions not supported by empirical evidence, include 18 papers from which 7 articles (i.e., 8.00%) are literature reviews, while 11 papers (i.e., 13.00%) are structured as commentary or normative/policy contributions. However, based on the assumption that CE has emerged from policy legislation rather than academics [9], theoretical articles can make a valuable contribution to critically analysing the paradigm transition required at the European and international levels. Thus, these contributions could enrich the academic debate and establish a foundation for future research.

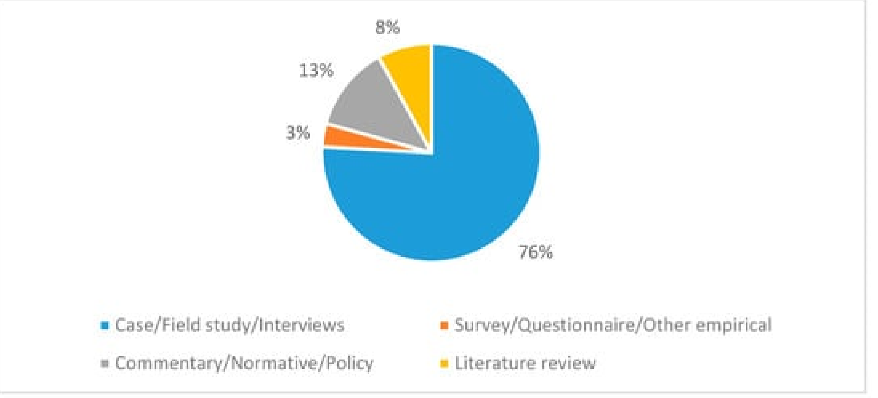

Figure 5. Research Methods.

1.3. Scientific Field

Analysing the international scientific literature, several approaches to CE emerge. These approaches are observed mainly due to the varied perspectives of analysis perspectives adopted by scholars of different disciplines. However, each approach can be perfectly integrated with the others because of the need to address environmental challenges[10]. In this context, this goal can be achieved through important inter-disciplinary efforts [11]. For this reason, it has been decided to assess the scientific field of each paper (Figure 6). Among the 87 articles selected, 22 papers (i.e., 25.29%) analyse CE through an environmental sciences point of view. The articles coded as âmixed fieldâ (5 articles, i.e., 5.75%) investigate the CE in the AFS through two or more scientific disciplines that work together to reveal and address the different issues of the same topic. Nevertheless, it is important to stress that the environmental sciences concerning the CE could be considered a transversal analysis approach to all disciplines. Only a small number of articles (7 articles, i.e., 8.04%) belong to the category âBiology/Chemistryâ; this result is entirely in line with one of the exclusion criteria defined in the selection process followed in this SLR. The majority of the articles (34 articles, i.e., 39.08%) discuss the adoption of CE from a managerial point of view, providing an environmental focus. Considerable attention has also been dedicated to this topic by agricultural science, which provides 19 scientific articles (i.e., 25.29%).

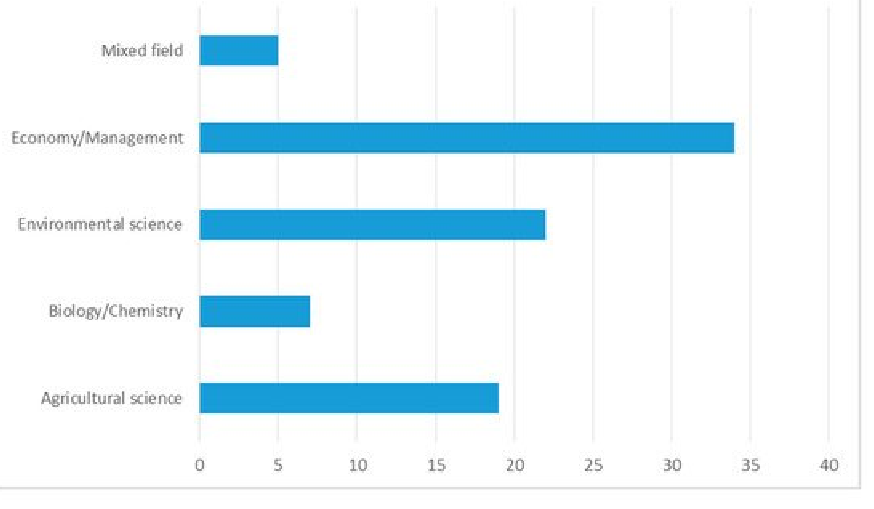

Figure 6. Scientific Field.

1.4. Focus on Tools Implemented

In relation to the fourth category âFocus on tools implementedâ, Figure 7 illustrates the distribution of 87 articles per tool.

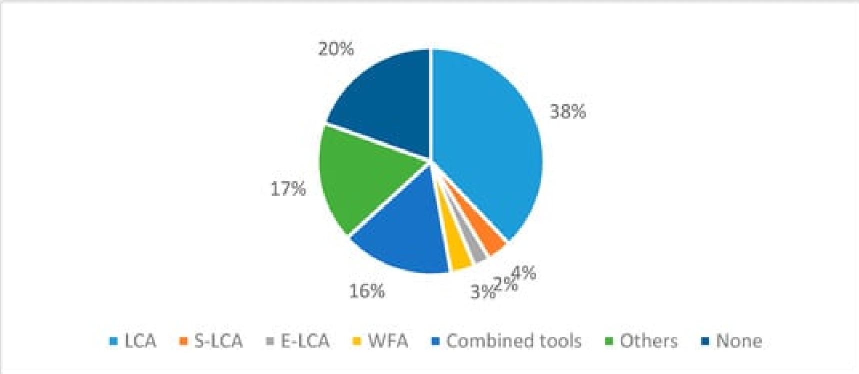

Figure 7. Tools implemented.

Life Cycle Assessment (LCA) is the most used tool (33 articles, i.e., 37.93%) and is based on an iterative process proposed by the international standard UNI EN ISO 14040:2006 (Principles and framework) and by UNI EN ISO 14044:2006 (Requirements and guidelines); it is composed of by four steps, i.e., goal and scope definition, inventory analysis, impact assessment and interpretation[12]. LCA is a versatile tool that can be used both (1) to assess environmental impacts to improve production or optimize resource management (e.g., water, energy, gas, etc.), and (2) to support policy interventions by identifying drivers for reducing the environmental burden of agriculture and food systems [13]This trend is justified by the common agreement that LCA is the tool that allows for better evaluation of the balance between efforts and benefits in implementing CE solutions at the micro level.

Nevertheless, LCA is only one of the assessment tools available. In fact, other instruments are taken into account in this analysis, i.e., S-LCA (3 articles, i.e., 3.45%), E-LCA (2 articles, i.e., 2.30%) and WFA (3 articles, i.e., 3.45%), although they are less often adopted. The articles in which LCA has been used in combination with other tools (i.e., Life Cycle Costing (LCC), Food Waste Energy Nexus, Life Cycle Environmental Assessment, SWOT, TOWS, Life Cycle Inventory and Externality Assessment (ExA)) have been grouped under the category âCombined toolsâ (14 articles, i.e., 16.10%). The low number of contributions in which more circular economy tools are used in an integrated way highlights a gap in the literature. This suggests the need to investigate the strengths and weaknesses resulting from a combined approach to assessing impacts in a triple-bottom-line approach.

With the aim of providing a complete analysis of the sample, technological tools used to convert food waste, by-products and co-products into resources able to be reintegrated in a new production process were also considered (i.e., rainwater harvesting tools, pelletization, Cornell Net Carbohydrate and Protein System, hot air drying or freeze-drying, solvent-based extraction and pressurized liquid extraction); these represented 17.24% of the total items (i.e., 15 articles). In such cases, these technologies are used in a micro and meso perspective. However, these studies âare often hampered by data discrepanciesâ. This entails that, in order to optimize CE practices in a macro perspective, digital technologies tools (i.e., data-driven analysis and mathematical and computer optimization models) could also be integrated.

Last, it is worth noting that 17 articles (i.e., 19.54% of the sample) have not taken into account impact assessment tools, thereby providing only a theoretical contribution on the topics covered by the SLR. Instead, a large portion of the sampled articles (17 articles, i.e., 19.54%) did not use any CE tool to assess the social, economic and environmental impacts of a product but analysed the agro-food SC from a theoretical point of view. The analysis shows that, on one hand, although the adoption of combined instruments is not widespread, it can help to provide a wider assessment of the sector in a triple-bottom line approach. On the other hand, it shows a growing interest of research towards the assessment of the technological tools provided for food waste and loss treatments.

1.5. Focus on the Type of the Agro-Food Supply Chain

The analysis of the categories âType of SCâ and âStage of SCâ aims to highlight the agro-food SC that has been most explored by scholars and to point out the literature gap to provide useful insights for future research.

As Figure 8 shows, the sub-category âAgricultureâ is the most analysed among the 87 reviewed articles, comprising 51.72% of the sample (i.e., 454 articles). This finding is observed because the agriculture SC is composed of a wide diversity of products; thus, each SC configuration is differentiated according to the specific characteristics of the food. The most investigated items of this sub-category are wine and olive oil. In the âDairyâ category, three articles (i.e., 3.45%) were detected. Concerning livestock farming, 11 scientific contributions were collected (i.e., 12.65%), focused on poultry, swine and beef sectors. In contrast, the âFish breedingâ category provided only a few contributions (5 articles, i.e., 5.75%). It is also worth noting that 23 articles (i.e., 26.43% of the sample) dealing with various SCs have combined agriculture with dairy, livestock farming or fish breeding to assess the entire AFS. Among these, three articles analysed local food SCs. In addition, part of the reviewed articles investigated the problem of food loss and waste to assess the related environmental impacts. Among these, Mouron et al.[14]investigated how food loss management could reduce environmental impacts. Following this approach, as stated above, some scholars analysed different technologies for food waste treatment to use residues from animal feed and biofertilizers or to turn them into energy. Last, only one article is focused on food redistribution.

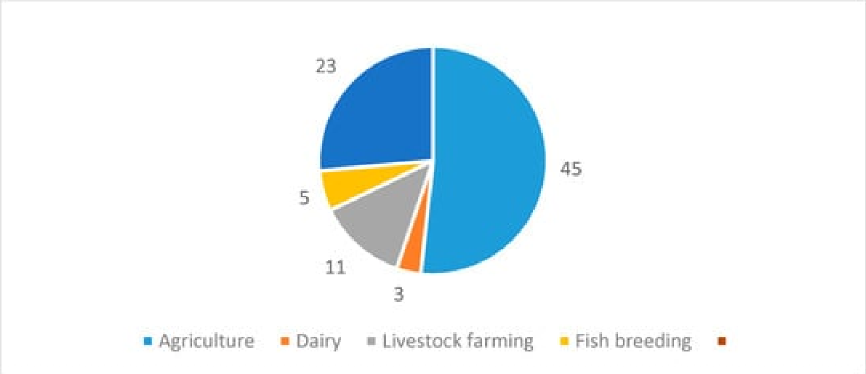

Figure 8. Type of Supply Chain.

1.6. Focus on the Stage of the Agro-Food Supply Chain

Although the dominant perspective considers that the ASC should be analysed in a âfarm-to-forkâ approach to assess the adaption of CE models and tools, some authors have focused their research on a specific stage of the SC. Adapting the classification previously developed by Yakovleva et al.[15], the analysis has been carried out in the following phases: production, processing, retail and consumption (Figure 9). Contributions that have analysed all the stages of the agro-food SC have been grouped in the category âThe whole SCâ. Most of the selected articles have investigated the entire SC, with 43 contributions (i.e., 49.42%). Less attention is given to consumption (4 articles, i.e., 4.60%) analysed from the perspective of waste generation. The lack of scientific production related to this stage is in contrast with the high impact that the household sector has in the production of food residue. In addition, the literature shows that the lowest food waste production, from a life cycle perspective, is connected to the retail stage (1 article, i.e., 1.15%). This shows the need to define strategies and best practices for the collection and transport of food waste, thereby creating new business opportunities. The cultivation and breeding stages are grouped in the sub-category âproductionâ, which provides 14 articles (i.e., 16.10%), while the processing of raw materials has been investigated by a greater number of scholars, covering 28.73% of the sample. This could be justified by the fact that, only recently, the attention of organizations such as Food and Agriculture Organization (FAO) and the Ellen McArthur Foundation has shifted from optimising production processes to responsible consumption.

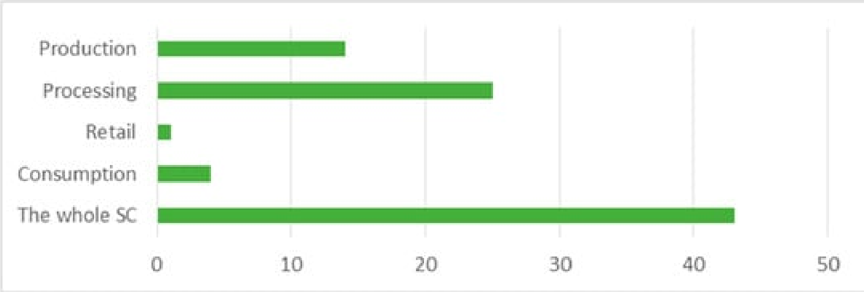

Figure 9. Stage of the Supply Chain. Adapted from Yakovleva et al. (2004).

1.7. Comparative Analysis between the Environmental Assessment Tools Implemented and Type of Supply Chain

To provide a comprehensive framework of the scientific literature concerning the CE applied to the ASC, a joint analysis has been carried out to assess each SC stage, the type of tool implemented, the perspective of the analysis adopted and the geographical reference. In addition, in keeping with several scholars[15], the industrial symbiosis dimension on three levels has been analysed: the macro level (international), the meso level (state, province and city) and the micro level (organization). Among the articles analysed in the sample of the present SLR, the contributions that provide an analysis perspective of CE tools applied to a specific product were selected. This perspective of varied analysis aims at highlighting the different assessment tools used for agricultural products and for dairy, livestock farming and fish breeding products, as summarized in Table 5.

Table 5. Comparative analysis between environmental assessment tools and type of supply chain.

Authors	Geographical Location	Supply Chain	Product	Tool	Industrial Symbiosis Dimension
MartÃnez-Blanco et al. (2009)	Barcelona	Agriculture	Tomato	LCA	Meso
Arnal et al. (2018)	Italy	Agriculture	Tomato	LCA	Meso
Mouron et al. (2016)	Swiss	Agriculture	Potato	LCA	Meso
Salomone and Ioppolo (2012)	Sicily	Agriculture	Olive oil	LCA	Micro
Stillitano et al. (2019)	Sardinia	Agriculture	Olive oil	LCA, LCC	Meso
Tsarouhas et al. (2015)	Greece	Agriculture	Olive oil	LCA	Meso
Arzoumanidis et al. (2014)	Italy	Agriculture	Wine	Simplified LCA	Meso
Bonamente et al. (2015)	Italy	Agriculture	Wine	WFA	Micro
Martucci et al. (2019)	Italy	Agriculture	Wine	S-LCA, VIVA	Meso
Aivazidou and Tsolakis (2020)	Italy	Agriculture	Wine	WFA	Meso

Authors	Geographical Location	Supply Chain	Product	Tool	Industrial Symbiosis Dimension
Falcone et al. (2016)	**Calabria**	**Agriculture**	**Wine**	**LCA, LCC, MA**	**Meso**
Balafoutis et al. (2017)	**Greece**	**Agriculture**	**Wine**	**LCA**	**Micro**
Pires Gaspar et al. (2018)	**Beira**	**Agriculture**	**Peach**	**E-LCA**	**Meso**
Antonelli and Ruini (2015)	**Italy**	**Agriculture**	**Pasta**	**WFA**	**Micro**
Wang et al. (2015)	**Jilin (China)**	**Agriculture**	**Maize**	**CFA, LCA**	**Meso**
Neira (2016)	**Ecuador**	**Agriculture**	**Cacao**	**LCA**	**Meso**
Giraldi-DÃ¬az et al. (2018)	**Mexico**	**Agriculture**	**Coffee**	**LCA**	**Meso**
Owusu-Sekyere et al. (2016)	**South Africa**	**Agriculture**	**Milk**	**WFA**	**Meso**
GrÃ¶nroos et al. (2006)	**Finland**	**Agriculture**	**Milk**	**LCI**	**Meso**
Bava et al. (2018)	**Italy**	**Agriculture**	**Grana Padano**	**LCA**	**Micro**
GarcÃ¬a-Gaudino et al. (2020)	**Spain**	**Livestock farming**	**Swine**	**LCA**	**Meso**
Presumido et al. (2018)	**Portugal**	**Livestock farming**	**Beef**	**LCA**	**Meso**
Philis et al. (2019)	**Sweden**	**Fish breeding**	**Salmon**	**LCA, LCIA**	**Macro**

At the micro level, in agriculture production, scholars have proposed LCA, WFA and CFA assessment methodologies. In particular, Salomone and Ioppolo highlighted that the use of the LCA methodology could support the decision-making process connected to âthe definition of an environmental chain strategyâ[16] . Concerning the WFA, Antonelli and Ruini [17], focusing their analysis on water management in the pasta production process, analysed some corporate strategies to achieve more sustainable water use, showing also that âthe largest share of the water footprint of pasta relates to the cultivation phaseâ. This level of analysis encourages companies in the adoption of CE tools with the aim of directing production and business models towards a sustainable approach. However, some scholars have stressed the need for a paradigm shift at a SC level rather than individual company level. Consistent with this assumption, most researchers have focused their work at a meso level, analysing the whole production chain in a wider area. In this perspective, LCA emerges as the most suitable tool used by scholars to assess the environmental impacts both of agriculture and the livestock sector. However, it seems necessary to underline that this result is a consequence of the theoretical approach adopted ex ante in the developed framework.

Scholars have used LCA to investigate agriculture supply chains as follow. MartÃnez-Blanco et al.[18]used LCA to assess the environmental impact of compost use in tomato cultivation in Barcelona, highlighting that it provides less impact than mineral fertilizer. Concerning olive oil production, Arzoumanidis et al. [19] investigated the use of a simplified LCA, such as BilanProduit, CCaLC, and VerdEE, suitable for the small- and medium-sized enterprises (SMEs) characterized by a lack of resources, highlighting that the results from the simplified LCAs are not always in line with the standard LCA. The minimization of negative impacts on the environment through the implementation of precision viticulture techniques is explored by Balaufotis et al. [20], who use LCA to identify the effects of variable rate applications on vineyard agro-ecosystems. The cereal sector has been analysed from a carbon footprint perspective by Wang et al. [21], who provide a clear understanding of the carbon footprint of maize production through the use of LCA. Concerning the social aspects of sustainability, Martucci et al. [22] provided a comprehensive overview of the VIVA project and of the S-LCA methodology to assess the negative and positive social impacts generated by wine production from a life-cycle perspective. The combined use of assessment tools is less used by scholars. However, some contributions have been detected from the reviewed articles. In particular, Stillitano et al.[23] basing their analysis on the economic and environmental impacts of innovative technologies in olive oil production, have implemented both the LCA and Life Cycle Costing (LCC) methodologies. Meanwhile, combining LCA, LCC and Multicriterial Analysis (MA), Falcone et al. [24]presented a sustainability assessment of different wine-growing scenarios in Calabria that combined environmental and economic insights.

At the macro level, the analysis of the sample shows a literature gap concerning this dimension. Indeed, only one article has investigated the fish breeding SC from a macro-level perspective; it did this by comparing the environmental impacts of different salmon aquaculture production systems. This shortage of contributions should be justified by the direct proportionality between the dimension of analysis and the complexity in implementing CE tools.

Starting from the state-of-the-art research provided, future research directions are presented in the following section.

Conclusion

The agro-food sector will face new challenges in a future business scenario in which resource efficiency and innovative technologies to reduce food loss and waste along the supply chain provide opportunities for promoting the transition towards more sustainable performance and an economically viable future. In particular, it is necessary to consider the combined environmental and socio-economic benefits of food waste and loss reduction. According to a study conducted by the FAO, reducing food loss and waste have a positive impact on the decrease in GHG emissions and on lowering pressure on land and water resources but also on suppliersâ profits and consumersâ well-being. Food suppliers, for example farmers, processors, transporters, retailers and food service providers, can increase their productivity by reducing food loss and waste, and they may also improve their reputation for environmental stewardship and strengthen customer relations. Consumers who reduce their food waste save money to spend elsewhere. Moreover, reducing food loss and waste presents unique opportunities to create value, local businesses and jobs, and thus new economic avenues. The results presented here highlight the necessity of a collaborative approach among the business community, policy makers and institutions in order to embrace sustainability as a business imperative and of adopting models that create shared value and drive systemic change towards circular economy goals. However, this study has several limitations. The main limitation is the subjective component in the choice of keywords, which has conditioned the results. In addition, the inclusion and exclusion criteria defined ex ante in the search strings may have also influenced the results, excluding some relevant articles. Since the analysis provides a general framework of the AFS, the study presents limitations related to the specific SCâs peculiarities. Therefore, it is almost utopian to define CE models that can be adopted homogeneously by the whole AFS. For this reason, product-based research can provide the basis for a more detailed analysis to investigate the most appropriate models and tools for each SC. Moreover, despite the pivotal role of retailers and consumers in the agri-food supply chain to efficiently implement CE models, future research should be more focused on retail and consumption. Furthermore, considering these reflections, it is clear that the ASC is a highly complex network, and it would be important for future research to concentrate on the integration of different stages.

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