proceedings

MDPI

Proceeding Paper

Charting the Landscape: Perspectives on Green Innovations in Agriculture †

Fernanda Sperotto * and Iván Tartaruga

Centre of Studies in Geography and Spatial Planning (CEGOT), Faculty of Arts and Humanities, University of Porto (FLUP), 4150-564 Porto, Portugal; itartaruga@letras.up.pt

* Correspondence: fsperotto@letras.up.pt

† Presented at the XVIII International Seminars on Overarching Issues of the European Area, Porto, Portugal, 23–26 May 2024.

Abstract: Concern over the impacts of climate change has significantly increased. While these effects are evident across various contexts, this study focuses on how the scientific literature has addressed the role of green innovations in agriculture. A bibliometric analysis was conducted to understand the structure and evolution of this topic over time. The results confirmed a recent increase in scientific publications and highlighted new research directions, such as identifying the agricultural subsectors most positively impacted by green innovations.

Keywords: eco-innovation; sustainability; scientific mapping

Academic Editors: Helena Pina, Diogo Miguel Pinto, André Samora-Arvela and Felisbela Martins

Published: 20 January 2025

Citation: Sperotto, F.; Tartaruga, I. Charting the Landscape: Perspectives on Green Innovations in Agriculture. *Proceedings* **2025**, *113*, 13. https://doi.org/10.3390/proceedings2025113013

1. Introduction

The effects of climate change are already being felt in all economic activities. In agriculture, the increased incidence of extreme events and the excess and scarcity in water availability have reduced crop expectations and heightened concerns about food security. In addition to hunger affecting about 10% of the world's population, growing urbanisation further reinforces the need to promote changes in the agri-food system [1]. Providing the right technologies to ensure economic, social, and environmental sustainability is crucial for the new agri-food system. The development and dissemination of green innovations aimed at agricultural activities need to contribute greatly to the transformations that the agri-food system needs. These innovations are significant for activities in agriculture because they can mitigate and even nullify the harmful effects of production or consumption on the environment [2,3]. In this context, this study's objective was to analyse how the scientific literature has addressed the role of green innovations in agricultural activities. It is essential to highlight that most studies on green innovations (environmental innovations or eco-innovations) examine industries. For this purpose, a bibliometric analysis was conducted based on articles published on green innovations and agriculture. In addition, we identified the most eco-innovative agricultural activities. This article is organised as follows: Section 2 deals with the methodology applied in the analysis; Section 3 presents the results; and, finally, Section 4 presents the conclusions of the study.

2. Material and Methods

In this study, we examined scientific articles, through a bibliometric analysis, that addressed green innovations in the context of agricultural activities. We collected data from the Scopus database (28 March 2024). The screening included the terms "green innovations" and "agricultural" (including synonyms of these expressions) in the titles, abstracts and

keywords. This resulted in the collection of 569 studies published between 1976 and 2024. We used the Biblioshiny package and Bibliometrix (R software, version 4.4.1.) to measure bibliometric parameters [4]. The research was carried out in two stages: 1st, we elaborated on relational co-citation analyses to detect the theoretical–methodological connections that guide a given research field; 2nd, we performed scientific mapping to observe the conceptual structure behind producing these studies and their thematic evolution according to the research area [5]. To achieve this, we constructed an adjacency matrix and considered two network indices: centrality (which indicates the number of connections that a node establishes in a network) and density (which reveals the proportion of connections). The intersection of these measures resulted in a diagram segmented into four quadrants: the upper-right quadrant represents motor themes (i.e., the most developed and important themes for the research field, characterised by high centrality and density); the lower-right quadrant represents fundamental and transversal themes (which are highly important and linked to other themes in the area but still underdeveloped); the lower-left quadrant represents emerging or declining themes (underdeveloped themes with few connections to other themes, presenting low centrality and density); and the upper-left quadrant represents highly developed but isolated themes [4].

3. Results

We identified 569 studies published between January 1976 and March 2024 that address the theme of green innovations from the perspective of agricultural activities. Overall, scientific research on this theme has grown significantly in the last four years.

Five articles represent the most referenced contributions. The first is a study by Mirabella et al. [6], which analysed the problem of food manufacturing waste and defended the potential of industrial symbiosis to recover waste resulting from food processing. The second study, by Matos and Hall [7], analyses a case study on agricultural biotechnology using the life cycle assessment approach. Padel [8] investigated studies that analysed organic farms in several countries. Notarnicola et al. [9] examined the environmental impacts of food consumption and identified that the agricultural phase is the stage that has the highest impact on all types of food analysed. Finally, Geels et al. [10] discussed the sociotechnical dynamics of low-carbon transitions and highlighted that agriculture activities are part of a very dispersed regime.

Figure 1 presents the evolution of this conceptual field through keyword co-occurrence, subdivided into five periods. Between 1976 and 2010, articles addressing green innovations in agriculture highlighted terms like “innovation”, “green innovation”, and “sustainable agriculture”. From 2011 onwards, new words emerged, such as “sustainable development”, “transition”, “biofuel”, and “food security”. Specifically, in the 2015–2018 period, terms like “climate change”, “sustainability transition”, “circular economy”, and “biotechnology” appeared. In the last two segments, it is essential to note the appearance of terms associated with significant actions to mitigate climate change, such as the Sustainable Development Goals and sustainability-oriented innovation.

The synthesis of the thematic map indicates, through the arrangement of keywords, which themes are motor, basic, emerging/declining, and niche themes. As emphasised in Section 2, the intersection of relevance parameters (centrality) and development (density) allows us to identify whether a keyword is related to a more developed field of research (motor themes), is a more transversal term linked to fundamental themes (basic themes), is a term with little development but connected to other research areas (emerging/declining themes), or is a niche theme, i.e., is highly developed but is at a stage of little connection with other themes. Themes guiding studies on green innovations and agricultural activities address aspects related to precision agriculture and the supply chain (Figure 2). In

turn, "green innovation", "sustainable development", "climate change", "sustainable", and "sustainable agriculture" were transversal topics linked to fundamental themes. In the quadrant of niche themes, we observed five terms being analysed more in isolation, such as "competitiveness", "absorptive capacity", "corporate social responsibility", and "biofuel". Finally, "absorption" appeared to be underexplored, while "agricultural innovation" seemed to be an expanding term closely related to niche themes.

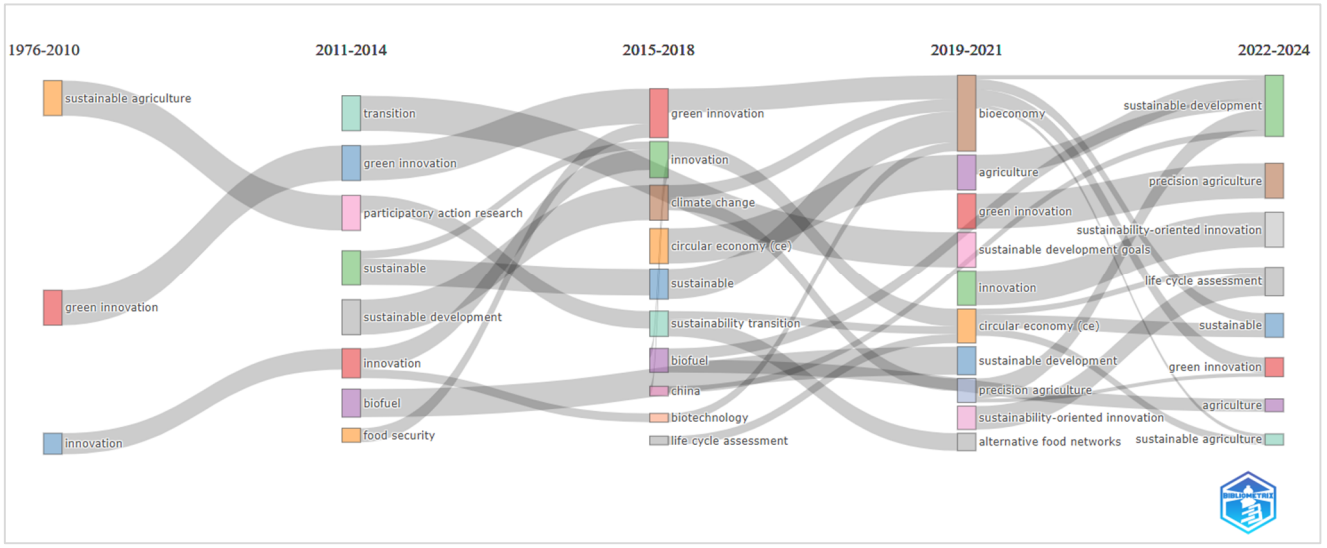

Figure 1. Evolution of the conceptual field of and scientific articles on green innovations and agriculture.

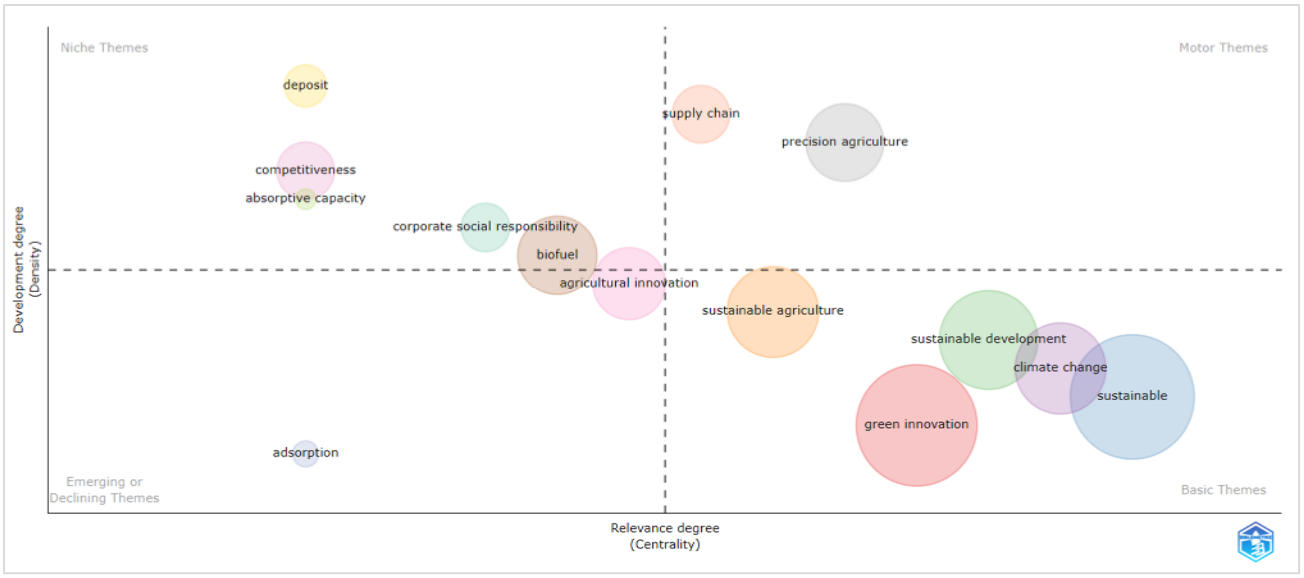

Figure 2. Thematic map according to of scientific articles on green innovations and agriculture.

Beyond scientific mapping, we aimed to identify, through keywords, the activities explored in studies on green innovations and agriculture. In this examination, we identified five categories. The main one encompasses techniques and specific cultivation and exploration segments, such as organic agriculture, organic food, aquaponics, agroecology, bioeconomy, bioenergy, bioplastics, biotechnology, and urban agriculture. The second main category is food production. This category includes aquaculture (salmon, fish farming, and seafood), land cultivation (bananas, cereals, chilli, cocoa, coconut, coffee, legumes in general, lettuce, rice, sugar, sunflower, tea, yeast, soybean, and sorghum), animal farming

(honey, goat, and sheep), and industrial processing (meat, wine, and oil palm). The third category relates to renewable energy production, such as biofuels (biogas, biomass, biodiesel, and agrofuel). The fourth group is associated with raw material extraction (bamboo, cotton, and wood) and industrial activities (except food and beverages) such as pulp and furniture. Finally, the fifth group relates to agritourism activities (hotel and rural tourism).

4. Conclusions

This study aimed to analyse how the scientific literature has addressed the role of green innovations in agriculture. The results indicated that, although most articles on the topic are not recent, there has been a rapid growth in the number of publications since 2021. This increased interest in the topic is mainly related to the intensification of climate disturbances and corresponding actions and policies to mitigate their impacts. It was interesting to observe the evolution of the topics analysed in the scientific literature on green innovations and agriculture and to verify their diversity and relevance. Between 1976 and 2010, the topics guiding the studies were mainly focused on just three themes—sustainable agriculture, innovation, and green innovation—but from 2011 onwards, new concerns and perspectives began to guide research, such as a focus on food security, circular economy, and biotechnology. Similarly, the thematic map indicated that research on green innovations and agriculture has focused on topics such as precision agriculture and the supply chain (motor themes), climate change and sustainable agriculture (basic themes), corporate social responsibility and biofuel (niche themes), and agricultural innovation (emerging themes). Another relevant result of this study was the mapping of the activities analysed in the studies, such as specific cultivation and exploration techniques and segments, food production, and renewable energy generation. These subsectors, which are directly or indirectly related to agriculture, are the most prone to and/or demanding of green innovations. In future research, we aim to deepen our analysis by selecting articles that have analysed case studies of green innovations in agriculture.

Author Contributions: Conceptualization, F.S. and I.T.; methodology, F.S. and I.T.; validation, F.S. and I.T.; formal analysis, F.S. and I.T.; writing—original draft preparation, F.S. and I.T.; writing—review and editing, F.S. and I.T.; visualization, F.S. and I.T. All authors have read and agreed to the published version of the manuscript.

Funding: This research received support from the Centre of Studies in Geography and Spatial Planning (CEGOT), funded by national funds through the Foundation for Science and Technology (FCT) under the reference UIDB/04084/2020.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: No new data were created or analyzed in this study. Data sharing is not applicable to this article.

Conflicts of Interest: The authors declare no conflicts of interest.

References

1. Food and Agriculture Organization of the United Nations (FAO). *The State of Food Security and Nutrition in the World 2023. Urbanization, Agrifood Systems Transformation and Healthy Diets Across the Rural–Urban Continuum*; FAO: Rome, Italy, 2023. [CrossRef]
2. El Bilali, H. Relation between innovation and sustainability in the agro-food system. *Ital. J. Food Sci.* **2018**, *30*, 200–225. [CrossRef]
3. Tartaruga, I.; Sperotto, F.; Carvalho, L. Addressing inclusion, innovation, and sustainability challenges through the lens of economic geography: Introducing the hierarchical regional innovation system. *Geogr. Sustain.* **2024**, *5*, 1–12. [CrossRef]
4. Aria, M.; Cuccurullo, C. Bibliometrix: An R-tool for comprehensive science mapping analysis. *J. Informetr.* **2017**, *11*, 959–975. [CrossRef]

5. Cobo, M.J.; López-Herrera, A.G.; Herrera-Viedma, E.; Herrera, F. An approach for detecting, quantifying, and visualizing the evolution of a research field: A practical application to the Fuzzy Sets Theory field. *J. Informetr.* **2011**, *5*, 146–166. [CrossRef]
6. Mirabella, N.; Castellani, V.; Sala, S. Current options for the valorization of food manufacturing waste: A review. *J. Clean. Prod.* **2014**, *65*, 28–41. [CrossRef]
7. Matos, S.; Hall, J. Integrating sustainable development in the supply chain: The case of life cycle assessment in oil and gas and agricultural biotechnology. *J. Oper. Manag.* **2007**, *25*, 1083–1102. [CrossRef]
8. Padel, S. Conversion to Organic Farming: A Typical Example of the Diffusion of an Innovation? *Sociol. Rural.* **2001**, *41*, 40–61. [CrossRef]
9. Notarnicola, B.; Tassielli, G.; Renzulli, P.; Castellani, V.; Sala, S. Environmental impacts of food consumption in Europe. *J. Clean. Prod.* **2017**, *140*, 753–765. [CrossRef]
10. Geels, F.; Sovacool, B.; Schwanen, T.; Sorrel, S. The Socio-Technical Dynamics of Low-Carbon Transitions. *Joule* **2017**, *1*, 463–479. [CrossRef]