

Knowledge Evolution in Agroecology in Mediterranean Areas: A Bibliometric Analysis

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Abstract The loss of productivity of agri-food systems today is known, partly related to biodiversity loss. To reverse this situation, adopting sustainable agri-environmental practices has been proposed. However, there are not enough studies in the scientific literature to explain why in-depth transformations to sustainable agroecological models are not taking place at all scales and dimensions. Therefore, based on the number of publications and trend topics, this study aims to analyse the evolution of knowledge in “agroecology” and see if its development is linked to climate policies and agreements. A survey of all the scientific articles collected on the Web of Science (WoS) between 1992 and 2022 by affiliated authors from France, Spain, Italy, Portugal, and Greece is carried out. For the analysis, a bibliometric analysis was performed (with R 3.6.2 (Biblioshiny package)). The first publications were observed in 1992. More than 95% of the publications took place in 2011. French research institutions led this trend, publishing 55% of the articles. The evolution of knowledge observed over the last few years has been linked to the transition towards sustainable agriculture through the study of agroecological practices, e.g., “agroforestry”, able to face different challenges related to loss of “biodiversity” and “climate change.”

Keywords: sustainable agriculture, agrobiodiversity, agroecology practices, scientometrics analysis, biblioshiny.

1. Introduction

The ability of the agricultural systems to contribute to Goal 2.4 of the Sustainable Development Goals (SDGs), which underpin the 2030 Agenda, has been questioned. One of the reasons is the vulnerability developed by plants and animals to pests and diseases due to the increasing loss of biodiversity, combined with the negative impacts of conventional agricultural practices and climate change, resulting in intensification and reliance on fewer species for food, making the agri-food production system more fragile and food security more difficult to achieve. Therefore, an alternative approach to the conventional and

industrial production model, based on agricultural sustainability, is required, whose foundations are based on the theory and methodology agroecology approach (Altieri, 2009; Wezel *et al.*, 2020). An alternative could be addressed by adopting more sustainable agricultural practices (cover crops, permanent pastures, agroforestry, ...), together with a more in-depth understanding of the socioeconomic, cultural and environmental aspects of the territory's at different scales, levels, and dimensions (Gil *et al.*, 2020; Gliessman, 2016); HLPE, 2019; Padró *et al.*, 2020), supported by policy, values (Anderson *et al.*, 2021; Nyéleli, 2015) and research (Iocolo *et al.*, 2022). Despite all the above, it is observed that there is not enough knowledge to answer why profound transformations are not taking place in agriculture and food systems at all scales and dimensions, as highlighted in the High Level Panel of Experts (HLPE) report (2019). For this reason, this study aims to analyse, through the number of publications and trend topics associated with agroecology research, the efforts made by researchers to address the problems of the territory and its inhabitants and to analyse whether they are linked to climate policies and agreements.

2. Methodology

This study followed a bibliometric analysis methodology. Bibliometrics is a methodology of exploring scientific publications contained in a scientific database (e.g., Web of Science (WOS)), such as scientific articles (Wezel and Soldat, 2009), and their subsequent reference reports to provide a scientific field map of a topic using statistics (Wezel and Soldat, 2009). A statistical summary of the published study is offered through statistical tools and mathematical software to identify a research area's principal determinants and trends. The determinants could be traced by various bibliometric analytic techniques, which only employed (i) co-authorship (authors, institutions, and country), (ii) and co-occurrence (keywords).

2.1. Data Analysis and Statistical Methods

The first step in our bibliometric study for data collection and research question input was the selection on the WoS Clarivate Analytics website of (i) the search keyword “agroecology”; followed by (ii) the research area (country/regions, e.g., France, Greece, Italy, Spain and Portugal), based on the count of the Institutional affiliations given in published articles, and finally selecting the type of document as a scientific article (N=481). It was observed that data was only obtained for the period 1992-2022. The second step was to analyse the data using software R 3.6.2 (Biblioshiny package). Once the previous analysis of the agroecology topic evolution by year/country was done, the keywords were analysed, and then, analysed the keywords. For this, keyword authors were selected because they often provide more information about the aim and topic of the publication (Wezel and Soldat, 2009). This analysis’s result was a total of 1.683 keyword authors. With these author keywords, a trend topic analysis was carried out to analyse the most frequent topics per year (word minimum frequency=5; the number of words per year=3). For processing, biblioshiny is an application of the Bibliometrix web application (2023). Biblioshiny is an open-source tool for quantitative research in scientometrics and bibliometrics that includes the main methods of bibliometric analysis.

3. Results

3.1. The evolution of the number of studies of the agroecology discipline

Agroecology is a recent term in the European Mediterranean area. As can be seen in Figure 1, it was a Spanish institution that would be involved in the first publication made in the European Mediterranean area.

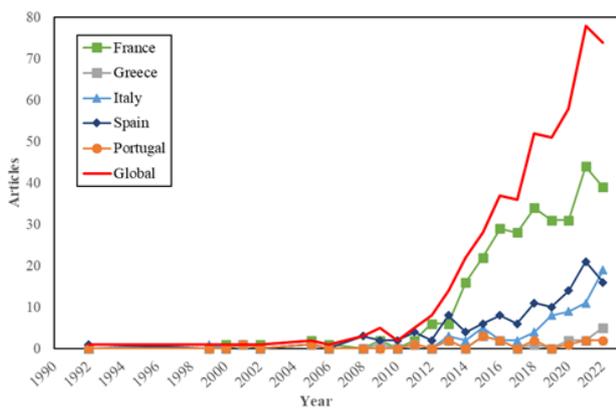


Figure 1 Countries’ Production over Time.

.It would not be until 1999, 2000 and 2001 that they would be observed in the following publications under the term “agroecology” (institutions belonging to Italy, France, Portugal and Greece, respectively). It has observed a timid and irregular scientific production in relation to this term until 2011 (growth rate of 8.84%). Year from which the scientific production would experience an increase (25.57%), representing more than 95% of the total scientific production collected in WOS, as Fig. 1. Since

2012, agroecology knowledge has been developed in French institutions ($\geq 55\%$) and, to a lesser extent, in Italian (13%) and Spanish (22%) institutions. In contrast, the results are consistent with what was observed in the analysis of Greece (3%) and Portugal (3%), where the study of agroecology will be more advanced in 2020 (Fig. 1).

3.2. Agroecology trend topic: Analysis

In the analysis of trend topics, the term “agroecology” was the only one observed between 1992 and 2011. This data and the trend in the number of publications observed up to 2011 served as the basis for defining the trending topic as the period under study, 2012-2022. The development of agroecology has focused on biodiversity, land use planning and organic farming practices. It was determined by the presence of the terms, for example, “agricultural development” and “organic farming” (before 2015). In 2015, the topics “intensification”, “agriculture”, and “production systems” reached the highest frequency in the study, Fig. 2. A second period, related to the “intensification” topic but on more specific knowledge (e.g., “forage system”, “grassland”, “weeds”, and “cropping system”) was the trending topics in 2016-2017) was observed. Topics related to management practices that develop productive and profitable “farming systems”, conserve the natural resource base, protect the environment and improve long-term health and safety at different scales and dimensions with the support of technology and “innovation”. The third period related to the environmental services provided by agroecosystems (“ecosystem services”, “biodiversity”, and “agroecology”; 2019, appear more frequently in journal articles). Finally, a fourth period appears with trending topics related to more sustainable agricultural practices (“cropping systems” and “agroforestry”) and more resilience to the negative impacts of climate change.

4. Discussion

Agroecology was established as a science in the late 1980s (Wezel *et al.*, 2009). Nevertheless, our analyses only found evidence in (WoS) in 1992, in one case of research by authors from Spain. It was only at the end of the 1990s and the early 2000s that the first articles published by Italian, French, Portuguese and Greek authors were observed. During the period 1990-2000, it has been detected that the first studies were related to the analysis of the structure and function of the landscape, the environment, and biodiversity. Wezel and Soldat (2009) found that from the 1990s onwards, there was an increase in the number of publications related to agroecological zone classification, land use characterisation, zoning or classification, land use planning and Geographic Information Systems (GIS). Such studies could also be related to the evolution of agroecology at different scales [(e.g., plot or field scale, agroecosystem level and food system scale (Gallardo-López *et al.*, 2018; HLPE, 2019; Wezel *et al.*, 2009)], linked to “production systems” and farming systems’ ecology. In 2015, we noted that “intensification” was an important topic. be related to the evolution of agroecology

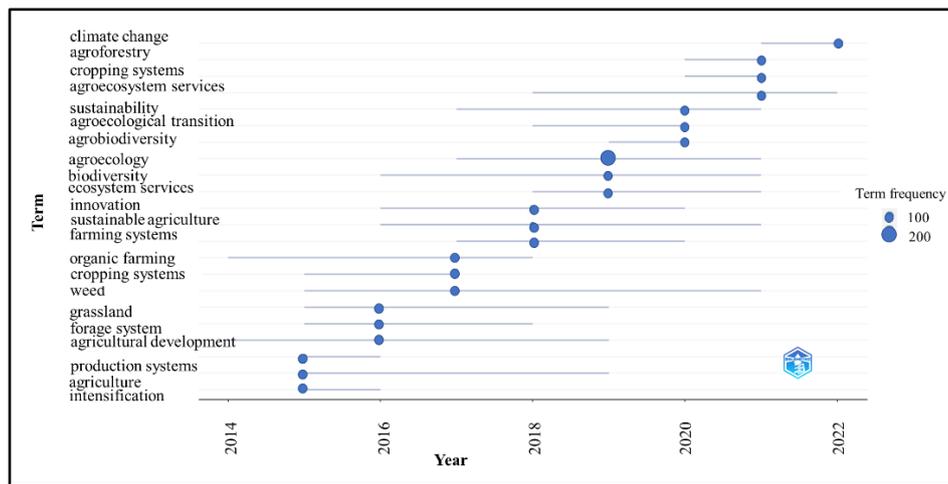


Figure 2 The trend topics associated with 'agroecology' scientific knowledge from 2012-2022. An analysis of the authors' keyword field. At the minimum, the keyword frequency was 5, and the annual number of keywords was 3.

at different scales [(e.g., plot or field scale, agroecosystem level and food system scale (Gallardo-López *et al.*, 2018; HLPE, 2019; Wezel *et al.*, 2009)], linked to “production systems” and farming systems' ecology. In 2015, we noted that “intensification” was an important topic. This term, in our study, appears related in time with the terms “agriculture” and “production systems” and less frequently with “agricultural development”, “forage system”, and “grassland” (most frequent terms in 2016) and “organic farming” v, “cropping systems” and “weeds” (most frequent terms in 2017), “sustainable agriculture” and “innovation” (most frequent terms in 2018). This relationship may be related to the evolution of the term. In the literature, it can be seen how authors, for example, Wezel *et al.* (2015), relate it to the evolution of the term “intensification” associated with three major uses (ecological intensification, sustainable intensification and agroecological intensification). Moreover, on the other hand, it has been observed how the first publications analysed in the first period (1992-2011) present “agroecology” as the topic of the moment. Perhaps this is due to increased research, formal teaching (as a subject in higher education) and non-formal education (Francis *et al.*, 2009; Migliorini *et al.*, 2018, Østergaard *et al.*, 2010; Rivera-Ferré *et al.*, 2021; Wezel *et al.*, 2020). It should be noted that “agroecology” is also one of the most frequent terms in the second period (2012-2022). In this second period, it was less frequent until 2017, becoming the most frequent in 2019. This fact could be related to the reorientation experienced by food systems with adopting sustainable agricultural practices and systems (“agroecological transition”) and supported by the change in the model for the development of social capital structures and governance through policies and strategies with the capacity to address the challenges facing agri-food systems (e.g., biodiversity loss, climate neutrality, and the enhancement of human rights). At all territorial levels and systems, to the socioeconomic and environmental needs and diversities of the territory, also considering the rights of citizens; so that during the transition process, they are not harmed due to the planned change (Miller *et al.*, 2022). The United Nations Climate Change Conference (COP25)

in 2019 concluded with the approval of the “Chile-Madrid Time to Act” Agreement, which lays the groundwork for countries to present commitments to reduce emissions and environmental degradation in 2020. This is what the European Union did through the European Green Deal [COM(2019) 640 final of 11.12.2019] through proposals (for example, the European Climate Law), strategies (e.g., the strategies presented in 2020 << Farm to Fork >> to increase the sustainability of food systems and the EU Biodiversity Strategy for 2030 (published in 20th of May 2020), aimed at protecting our planet's fragile natural resources (that could be therefore related to the most frequent words, for example, “biodiversity”, ecosystem services” in 2019 and “agrobiodiversity” in 2020). Furthermore, the European Green Pact also includes plans such as, for example, the Action Plan for organic production in the EU to reach 25% of agricultural land under organic farming by 2030, to achieve their objectives. With the support of the Common Agricultural Policy (CAP), an instrument of regulation and financial support for organic production through rural development commitments, with an additional stream of financing available through eco-schemes. Linked eco-schemes practices, “agroforestry”(initially supported by measures M222 and M8.2 in the CAP 2007-2013 and in the CAP 2014-2020, respectively) and “cropping systems” represent one of the most studied practices in our study (Aguilera *et al.*, 2020; Rodríguez-Rigueiro *et al.*, 2021). Practices related to environmental, climatological and animal welfare actions are framed within the strategic plans of the CAP (European Commission, 2021). Finally, from 2022 onwards, the most studied topic is “Climate Change”. The theme is mainly interrelated with food, the economy, natural resources, agriculture, and the environment, which are strategic elements of the transition towards sustainable agri-food systems (Schwarz *et al.*, 2022).

5. Conclusion

In the Euro-Mediterranean region, agroecology is a scientific field that has recently experienced increased

activity since the 2010s. Adopting a greater emphasis on a systemic and multidisciplinary approach since 2016, focusing on agroecosystems and their sustainability. In our work, we have identified four periods from which we intend to explain the evolution of knowledge in agroecology". It is observed that, recently, strategies aimed at the conservation of biodiversity and sustainable production are being defined. Highlight more studies on conserving ecological practices resilient to climate change, such as permanent grasslands, cover crops and agroforestry. However, a more detailed survey of agroecological practices is needed to define a global concept that supports decision-makers, politicians, technicians, end users and academic knowledge.

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