Origin, evolution, currents of thought, and methodological implications of the agroecosystem concept: a review

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ABSTRACT

The objective of the research was to analyze the different currents of thought and to describe the origin and evolution of the concept of agroecosystems across different studies.

Methodology. A state-of-the-art analysis of the agroecosystem concept was conducted using the Web of Science platform, considering 225 articles with the TITLE "Agroecosystem" AND KEYWORDS "Agroecosystem." Metrics such as year, country, sustainable development goals (SDGs), language, summary, and conclusions were also considered. A bibliometric analysis was performed using VOSviewer software, and graphs were created to visualize the bibliographic connections between the documents obtained from the Web of Science database.

Results. Articles from 1991 to 2024 were identified, with over 90% published from 2018 to the present. The top countries publishing this type of research are the USA, China, Canada, France, Germany, and Italy, accounting for 82% of the publications. The remaining 18% are spread across 44 countries worldwide. The predominant language is English (96%), followed by Spanish (3.1%) and Russian (1%).

Conclusions. The concept of agroecosystems is embedded in the social, cultural, political, and economic contexts, as all these aspects are directly related to agriculture, livestock, fishing, and other essential activities for feeding humanity. These activities are carried out within agroecosystems managed by humans for both commercial and self-consumption purposes, aiming to satisfy society's demand for food, goods, services, and inputs.

Keywords: Society, crops, environment, ecology, soil health

INTRODUCTION

The term ecology was coined by the German biologist Ernest Haeckel in 1870, referring to it as the study of the economy of nature; and today, many scientists define it as the science that studies the interrelationships between living organisms and their environment.

In a generalized way, agroecosystems (AES) can be defined as environmental systems modified and managed by humans to produce goods and services in a structured and diversified manner. Therefore, their conceptualization and application are adaptable to most of the living ecosystems on our planet. The idea behind agroecosystems is to conceive agriculture as a living, complex system that seeks to imitate natural processes and leverage ecological principles to increase productivity sustainably, conserving natural resources and promoting biodiversity (Stephen, 2015). It is known that agroecosystems integrate traditional knowledge of farmers with scientific advances in ecology, agronomy, and other disciplines to design agricultural systems that are resilient, efficient, and environmentally friendly. Additionally, they aim to promote crop diversification, the use of agroecological practices such as crop rotation, integrated pest management, organic fertilization, and the incorporation of biodiversity elements into agricultural systems (Méndez *et al.*, 2015).

The word agroecosystem is composed of two terms: agro-ecosystem; where agro refers to land, soil as a source of production; agriculture, derived from the Latin ager and cultura, is defined as the activity in which humans, in a given environment, manage natural resources, the quality and quantity of energy and information to produce and reproduce plants and animals to satisfy predominantly anthropocentric needs (Hernández, 1977). The concept of agroecosystems began to be used with the emergence of the journal Agro-Ecosystem (Harper, 1974). Three years later, the first seminar on Agroecosystems of Mexico was held in Mexico (Hernández, 1977). According to Hart (1979), an agroecosystem is an ecosystem that at least includes a population of agricultural utility; that is, it encompasses a biotic community and a physical environment with which this community interacts, and it typically includes populations of plants and animals. In this regard, it is important to mention that agroecosystems differ from natural ecosystems due to the presence of agricultural populations, and that the performance of an agroecosystem is regulated by human intervention. This intervention is generally planned, meaning that the farmer has a purpose to fulfill within the system and manages it by following a preconceived management plan that theoretically allows them to achieve specific objectives. Today, there are a number of definitions of agroecosystems because this term is a conceptual construct that refers to physical spaces that have been modified by humans to produce various social satisfiers, both material and non-material (Pérez, 1996). Agroecosystems, like ecosystems, include both biotic and abiotic components and the interactions between them. In this regard, Hernández (1977) mentions that an agroecosystem is an ecosystem modified to a greater or lesser extent by humans to use natural resources in the processes of agriculture, livestock, forestry, and wildlife production. Odum (1984) states that an agroecosystem is a domesticated ecosystem, with intermediate forms existing between natural ecosystems (such as grasslands, forests, etc.) and artificial ecosystems like cities. Conway (1987) mentions that an agroecosystem is an ecological system modified by humans to produce fiber or agricultural products. Marten (1988) states that an agroecosystem is a complex of air, water, soil, plants, animals, and microorganisms in a limited area that people have modified for agricultural production purposes.

The concepts and methodologies for agroecosystem analysis were developed at Chiang Mai University in Thailand by Conway (1986). This method is based on an ecological and

systematic approach to analyze agroecosystems in terms of their emerging properties such as productivity, stability, sustainability, and equity, and it was named Agroecosystem Analysis. Although agroecosystems are not exactly natural ecosystems, they can still be considered as ecosystems, and in general, all ecological concepts such as energy flow, material cycling, and others are applicable in their study. There are three types of agroecosystems: those with a crop subsystem (which can include annuals, perennials, forest trees, etc.), those with an animal subsystem, and those with both crops and animals (Krishna, 2013). Based on the above, the objective of the present research was to analyze the different currents of thought regarding the concept of agroecosystems, in order to describe the origin and evolution of the concept through various identified studies.

MATERIALS AND METHODS

Stage I. Information Search

In the first stage, a state-of-the-art analysis of the concept of agroecosystems was conducted through articles included in the platforms Google Scholar, Scielo, Web of Science, and Redalyc. A search was carried out using the word and concept of agroecosystem, which resulted in several articles being displayed. Those that contained the desired word in the title, abstract, and keywords were selected, resulting in a total of 137 articles. Subsequently, the Web of Science platform was used to conduct a more in-depth search and analysis, allowing the download of the document database. The search rubric TITLE "agroecosystem" AND + KEYWORDS "agroecosystem" was applied, resulting in a total of 225 articles.

Stage II. Information Analysis

A metrics analysis was conducted, which included the year, country of publication, Sustainable Development Goals (SDGs), language, DOE task, abstract, and conclusions. Additionally, a bibliometric analysis of the resulting articles was carried out using the VOSviewer software, a tool developed by the Center for Science and Technology Studies (CWTS) specifically designed to visualize bibliometric networks (Toro, 2017). This software generated graphs representing bibliographic connections between the documents obtained from the Web of Science database. These graphs included citations, keywords, years of publication, and other bibliometric elements (Guallar *et al.*, 2020). To represent the frequency of documents by country, the information was exported into a world map using Quantum GIS.

RESULTS AND DISCUSSION

Currently, there are a significant number of definitions of the concept of agroecosystems, and this is due to the fact that this term is a conceptual construction referring to physical spaces of various spatial dimensions that have been modified by humans to produce various social satisfiers, both material and non-material (Pérez, 1996). This concept has evolved over time and continues to undergo constant changes to this day, reflecting an increasing understanding of the complex interactions between the social, ecological, and economic components of agriculture. Below is a brief description of this ongoing evolution of the

concept of agroecosystems, clarifying that this evolution has not been linear, as different approaches coexist today, each with its own perspective: Early agronomic approaches (19^{th} century - early 20th century): focus on production – agriculture was viewed as a simple system for food production, with an emphasis on maximizing efficiency and yield (Liebig, 1843 and King, 1911). Agricultural ecology (mid-20^{th} century): recognition of ecological complexity – agriculture began to be understood as an ecosystem with interactions between crops, pests, natural enemies, and the environment (Odum, 1953 and Watt, 1968). Agroecology (1970s - present): holistic and social approach – agroecology became established as a discipline that seeks the sustainability of agricultural systems, integrating ecology, economics, and social dimensions (Altieri, 1987 and Gliessman, 2007). Agroecology for food sovereignty and social justice (current): focus on social justice and food – the importance of agroecology for the construction of just, equitable, and sovereign food systems is recognized (Holt *et al.*, 2013 and IPES-Food, 2016).

Some of the recent contributions to the concept of agroecosystems that have been identified are listed below. However, it is important to mention that this field of agroecosystems is in constant evolution, and it is highly likely that new contributions to this area of science will frequently emerge:

- **Agroecology as a Transdisciplinary Science**: This section acknowledges the need for a transdisciplinary approach that integrates different knowledge and perspectives to address the complexity of agroecosystems (Bacon and Koontz, 2015).
- **Focus on Resilience and Adaptation to Climate Change**: It highlights the importance of agroecology in building agricultural systems resilient to climate change and other environmental challenges (IPCC, 2019 and Gliessman, 2016).
- **Urban and Periurban Agroecology**: The fundamental role of urban and periurban agriculture in food security and the sustainability of cities is recognized (McClintock and Jabbour, 2014 and Orsini *et al.*, 2013).
- **Agroecology and the Sustainable Development Goals**: This approach recognizes the contribution of agroecology to achieving the Sustainable Development Goals (SDGs), such as food security, poverty, health, and climate change (FAO, 2018 and IPES-Food, 2016).
- **Agroecology and Social Justice**: The role of agroecology in building fair and equitable food systems that guarantee the right to food for all people is emphasized (Holt, 2017 and Desmarais and Wittman, 2019).

The emergent properties of agroecosystems are characteristics or behaviors that cannot be predicted from the properties of their individual components; they generally arise from the complex interaction between the different elements of the agroecosystem, such as crops, pests, natural enemies, soil, water, and climate, primarily. According to Conway (1987), Gliessman (2007), Altieri (1987), and Marten (1988), the main emergent properties —productivity, resilience, diversity, stability, and equity— are important for the overall sustainability of agriculture. Therefore, understanding these properties is crucial for designing and managing more resilient, productive, and equitable agroecosystems.

The health of agroecosystems is a relatively new concept, despite the fact that throughout history, agriculture has largely been based on the exploitation of natural resources, without much attention to the long-term sustainability of resources, leading to soil degradation, loss of biodiversity, water pollution, among other factors. In recent decades, there has been a growing interest in the health of agroecosystems due to various factors, such as increasing concerns about food security, climate change, environmental degradation, and others (Gliessman, 2007; Altieri, 1987; FAO, 2018). As a result, the health of agroecosystems is currently a major topic in most research areas, as new, more sustainable agricultural practices are constantly being developed, which in turn help protect the health of agroecosystems. It is worth mentioning that the indicators of agroecosystem health are variable and allow for the evaluation of an agroecosystem's status and its capacity to function sustainably. These indicators can be biological, physical, chemical, or socioeconomic in nature. The concept of agroecosystems has important methodological implications for agricultural research and management. These include the need for a holistic, multidisciplinary, participatory, long-term, systems-based, adaptive, and agroecological approach. According to Gliessman (2007), IFOAM (2008), and FAO (2018), the most relevant approaches include the holistic approach, multidisciplinary approach, participatory approach, long-term focus, participatory research methods, qualitative research methods, quantitative research methods, systems approach, adaptive approach, and agroecology approach.

It was found that, of the articles published between 1990 and 2023, 82% of the 225 articles found were published between 2018 and 2023. This indicates that most of them are recent, with an average of six years of age.

These articles present the latest research advancements focused on the study of agroecosystems worldwide, covering aspects such as soil, water, environment, society, and other disciplines.

On the other hand, the term Agroecosystems, implicit in the Sustainable Development Goals (SDGs), was found to be related as follows: 32% corresponds to the goal of life on land, followed by 25% for climate action, 21% for zero hunger, 7% for sustainable cities and communities, and finally, 6% for life below water. Regarding the language in which the 225 articles obtained from the Web of Science platform were written, it was found that 96% are published in English, followed by 3% in Spanish, and finally, the remaining 1% is written in Russian. These results show that the highest activity in research focused on and/or related to agroecosystem topics is in developed countries where the predominant language is English. However, it is worth mentioning that research on agroecosystems is also being conducted in Central American countries, but these studies are likely published in journals from other disciplines not included in the analyzed platform. The types of documents found in the Web of Science platform related to the word "agroecosystems" show that 88% of these documents are scientific articles, followed by 6% consisting of conference proceedings, and finally 3% being review articles, respectively. These data show a positive impact on the global scientific community, which is continually updating this type of information related to agroecosystems. In other words, science is in constant evolution, seeking new scientific contributions that will undoubtedly benefit society as a whole. Finally, in Figure 1, you can

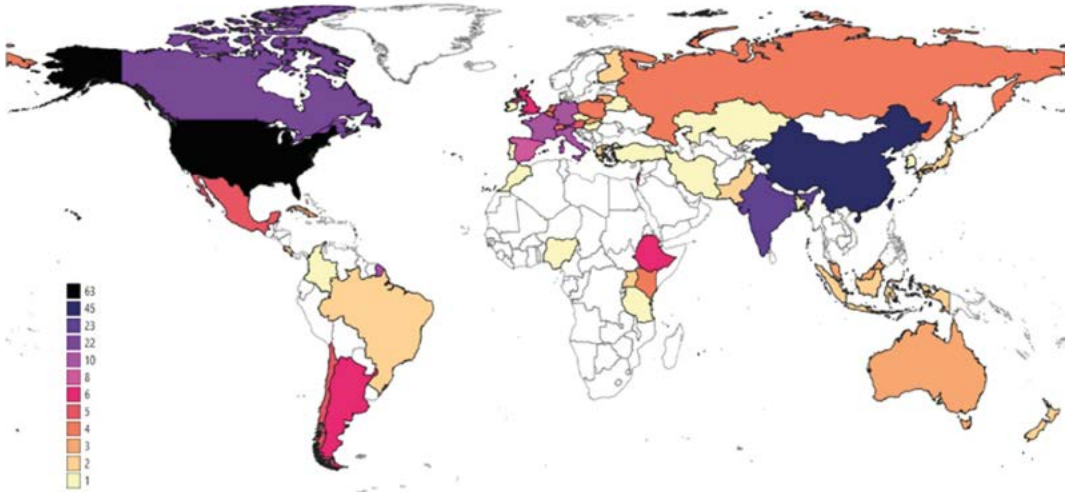

Figure 1. Number of documents published by countries worldwide, based on data obtained from the Web of Science platform for the 225 articles containing the term "Agroecosystems".

observe the countries where these types of documents have been published. The highest number of articles published corresponds to countries in South America, with the color indicating the number of publications related to the term "agroecosystems".

CONCLUSIONS

The activity carried out allowed for an expansion of the origin and concept of agroecosystems, which can generally be understood as the concept of AGS as an evolving conceptual construction in which reference is made to the use and application of geographic spaces of various sizes, where humans use them to select plants and animals to meet the constant demand for food and other requirements that society needs for survival on this planet. The concept of agroecosystems is implicit in the primarily social, cultural, political, and economic aspects and/or factors, as all these terms are directly related to agriculture, livestock, fishing, and other basic activities for human food production, which are developed through the agroecosystems managed by humans for commercial purposes or subsistence in meeting society's basic demands for food, goods, services, and inputs.

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