AGROECOLOGY AS A SOLUTION FOR AGRICULTURAL AND ENVIRONMENTAL SUSTAINABILITY: THE PERSPECTIVE OF BIOREGIONS

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Abstract
Sustainable agriculture is considered a crucial solution for developing technologies and practices that do not harm the environment, are accessible to farmers, and enhance food production. The current lifestyle of societies is widely regarded as the primary cause of environmental issues, leading to a slowdown in overall development, which must be addressed to ensure ecological sustainability. However, societal needs cannot be fully met based solely on the environmental dimension; economic, social, and cultural factors are equally important. This indicates that new approaches are necessary, which integrate biological and ecological processes into food production, reduce the use of non-renewable resources that harm both the environment and human health and effectively leverage the knowledge and capacities of local farmers. The growing interest in bioregions, grounded in agroecology principles, encompasses economic, environmental, and social challenges. It is part of broader discussions on the integration of food systems with local territories and cultural values, aiming to improve the quality of life in rural communities by making agriculture more profitable, creating new markets, promoting local tourism, reducing agriculture's environmental impact, conserving biodiversity, and encouraging local food consumption. However, a key question remains: can agroecology coexist with a highly formalized agricultural model without compromising its sustainability potential? Therefore, this study aimed to synthesise and analyse scientific knowledge on the concept of bioregions as a means of implementation agroecology, with a particular focus on its impact on local economies, social cohesion, and environmental sustainability.
Keywords: bioregions, agroecology, sustainable agriculture, territorial development.

Introduction

Contemporary food production systems are increasingly being subjected to critical evaluation due to their environmental and societal impacts (Proskina et al., 2024). Intensive agricultural models contribute to ecosystem degradation and the decline of biodiversity. In the long term, such an approach threatens environmental balance and reduces the resilience of food systems (Naglis-Liepa et al., 2022). At the same time, current consumption habits often do not align with the principles of sustainable development, reinforcing irreversible environmental and social consequences (Steier et al., 2017).

In this context, agroecology is gaining increasing importance as it offers a holistic approach to addressing the complex challenges faced by contemporary food systems. Scientific research has highlighted the importance of implementing biological and ecological practices that support natural processes, enhance biodiversity, and maintain soil health (Cote et al., 2019). Agroecology encompasses these principles, integrating agriculture and food production with environmental protection and social equity.

Although the theoretical potential of agroecology has been extensively studied, increasing attention is being directed toward its practical implementation in specific territorial contexts. One of the most promising possibilities to implement this approach is by drawing the concept of bioregions, which provides an integrated framework for applying agroecological principles in practice. The bioregional approach is regarded as one of the most effective tools for localizing agroecological principles and aligning them with regional development goals. Bioregions encourage the use of local resources, foster the development of local economies, and contribute to the preservation of cultural values, thereby enhancing the effectiveness and sustainability of agroecological strategies (Guareschi et al., 2020; Dias et al., 2021; Kraljevic & Zanasi, 2023). Although agroecology and the bioregional concept appear to be closely interconnected, their practical integration often faces a range of political, economic, and technological challenges. Furthermore, a limited understanding of the effectiveness of the bioregional approach and the prerequisites for its implementation across diverse contexts remains.

Wezel et al. (2018) observe that the challenges surrounding the implementation of agroecological principles primarily arise from the complex interplay between a diverse array of stakeholders – ranging from local farmers to policymakers, and from economic interests to social movements – all of whom play a vital role in advancing agroecology at multiple levels and in varied contexts. Although agroecological and bioregional approaches are conceptually aligned and share a common aim of fostering sustainable, locally grounded agricultural systems, their practical application is frequently constrained by ideological tensions and prevailing narratives rooted in conventional and industrial agricultural paradigms. Such tensions underscore the need for a balanced governance approach capable of integrating the scientific, practical, and social dimensions of agroecology into bioregional planning processes, while simultaneously respecting local cultural values and ecological boundaries (Matthews, 2022).

This study aims to synthesise and analyse scientific knowledge on the concept of bioregions as a means of implementation agroecology, with a particular focus

on its impact on local economies, social cohesion, and environmental sustainability.

Materials and Methods

This study adopts a qualitative approach to literature analysis, with a particular focus on a structured literature review and thematic analysis. The research examines academic publications from the past two decades featured in internationally recognised journals, alongside policy documents related to the development of agroecology and the bioregion concept across various European countries. The principles, benefits, and challenges of different approaches to sustainable agriculture are systematised in order to facilitate a comparative assessment of agroecology's potential, with particular attention given to the influence of bioregions on local economies, social cohesion, and environmental sustainability.

Results and Discussion

Sustainable agriculture approaches

In recent decades, the concept of sustainable agriculture has become a central topic of discussion among both academics and policymakers. A key issue within these debates concerns how to ensure food production that not only preserves natural resources but also fosters economic stability and social justice. According to the Food and Agriculture Organization of the United Nations (FAO, 2025), sustainable agriculture is defined as a system capable of maintaining high productivity over the long term, while safeguarding ecosystems and promoting social equity. Experts and researchers have proposed several approaches to achieve this goal. A comparison of these methods is provided in the table below to support a clearer understanding of their core principles and effects (Table 1).

Table 1

Key characteristics of sustainable agriculture approaches

Agricultural Approach	***Organic Agriculture***	***Regenerative Agriculture***	***Precision Agriculture***	***Conservation Agriculture***	***Agroecology***
Key Principles	Ban on synthetic chemicals, use of natural fertilizers	Soil regeneration, carbon sequestration, minimal soil disturbance	Digital technologies, GPS guidance, field sensors	Reduced tillage, cover crops, preserving natural cycles	Integration of ecological and social factors, local knowledge
Benefits	Improves soil fertility, promotes biodiversity, and reduces chemical residues in food.	Improves soil structure, increases carbon sequestration	Reduces chemical use, improves yield management	Reduces soil erosion, maintains fertility	Ensures social justice, supports local economy and environmental protection
Challenges	Limited yields, dependence on natural processes	Requires long-term commitment, initially lower productivity	High initial costs, technology accessibility	Requires specific farm management strategies	Requires paradigm shift in policies, market structures, and farmer education
Environmental Impact Indicators	Reduces water pollution, promotes biodiversity	High carbon sequestration, enhances biodiversity, reduces GHG emissions	Reduces input overuse and chemical runoff, but may increase energy use and e-waste.	Significantly reduces erosion, improves soil carbon retention	Promotes biodiversity, low GHG emissions, improves ecological resilience
Scalability & Applicability	Highly suitable for small to medium farms, limited large-scale use	Effective across scales with adaptation; best for medium-sized farms	Highly scalable, suitable for large farms with capital	Widely applicable, adaptable to various farm sizes	Flexible, but more common in smallholder and community farms
Policy/Market Support Availability	Supported by EU subsidies and certification programs	Growing support through climate initiatives and regenerative movements	Increasing support via agri-tech programs and innovation funds	Included in some agri-environment schemes	Recognized in policy discourse, but uneven institutional support
Researchers	Berbec et al., 2018; Özer & Dal, 2023; Naglis-Liepa et al., 2021; Fereira et al., 2020	Paustian et al., 2019; Dudek & Rosa, 2023; Rowntree et al., 2020	Gebbers & Adamchuk, 2010; Koloszycz et al., 2024; Zeverte-Rivza et al., 2024	Hobbs et al., 2007; Gemtaou et al., 2024	Altieri & Toledo, 2011; Wezel et al., 2018; Savels et al., 2020

Among the proposed approaches to sustainable agriculture, agroecology stands out due to its holistic perspective, which not only ensures sustainable production methods but also promotes social justice, local economic development, and environmental protection. The bioregional approach complements the implementation of agroecological principles by supporting agricultural systems tailored to the specific ecological and social conditions of a given region. As demonstrated by studies conducted in European countries, the adoption of the bioregional concept has encouraged the consumption of local products and

generated new economic opportunities in rural areas (Guarnacia et al., 2020; Lamine et al., 2023).

The Concept of Agroecology and Its Development

In its early stages of development, up to the 1950s, agroecology was considered a subfield of ecology with a focus on the interactions between plants and animals within agricultural ecosystems (Wezel et al., 2018). The first ideas of agroecology emerged in the early 20th century when scientists began to examine how biological and ecological factors affect agricultural practices. At this stage, particular attention was given to plant–soil relationships, the role of natural cycles, and the conservation of biodiversity.

In the 1950s, agroecology gained wider recognition as a scientific system that encompassed not only the study of ecological processes but also the analysis of agriculture considering the interactions between plants, animals, the environment, and humans within agricultural practices (Guzman & Woodgate, 2015). At this stage, the emphasis shifted towards the application of ecological principles to agriculture, which helped to develop new methods and approaches to sustainable food production.

Since the 1980s, agroecology has evolved into a multidisciplinary field encompassing environmental, social, and economic challenges. In response to the problems posed by industrial agriculture - such as soil degradation, biodiversity loss, and increasing dependence on chemical fertilisers and pesticides, practical agroecological initiatives began to emerge during this period, including permaculture, organic farming, and integrated pest management (Guareschi et al., 2020).

At the turn of the 20th and 21st centuries, agroecology came to be regarded not only as a scientific discipline but also as a socially driven movement and a set of agricultural practices (Savels et al., 2020). International organizations, such as La Vía Campesina, actively promote agroecological principles, emphasizing its potential to support small-scale farms, protect local ecosystems, and ensure sustainable food production (About La Via Campesina, n.d.). More recent studies increasingly frame agroecology as both a movement and a body of farming practices, rather than merely a scientific domain (Wezel et al., 2018), and highlight its potential as a viable solution for achieving the United Nations Sustainable Development Goals, which aim to reduce poverty (Wicki et al., 2025), ensure food security, and promote ecological well-being (Cote et al., 2019).

The ‘expansion’ of agroecology beyond the boundaries of the scientific sphere also gives rise to varying interpretations and definitions, which may lead to confusion and misunderstanding about how to apply the agroecological system to promote sustainable development. Summarizing scientific findings, the following dimensions of agroecology have been identified:

- Scientific approach – the application of ecological methods in crop cultivation and their interaction with the environment, including environmental, social, economic, and ethical aspects;
- Practical approach – preservation of biodiversity, management of soil fertility, and implementation of environmental protection measures to create productive and sustainable agricultural systems;
- Social movement – the promotion of sustainable agricultural practices and rural area development, mostly carried out by non-governmental organizations and local communities.

Changes within the agroecological system and the broad application of the term reflect a logical process of development. Initially existing solely as a scientific approach, agroecology has evolved into an active tool for the transformation of agriculture and rural development, applied in practice to provide sustainable solutions in both environmental and socio-economic contexts. In fact, the dimensions of agroecology can be interpreted as a reflection of the system’s historical development, with the use of bioregions representing the next logical step in advancing sustainability.

The Role of Bioregions in Sustainable Agriculture

The practical application of agroecology is closely linked to the concept of bioregions - an innovative new approach to rural development that encompasses social, environmental, economic, and ethical dimensions. However, there are notable differences between the concepts of agroecology and bioregions. Agroecology focuses on enhancing the ecological aspects of agricultural systems by integrating both scientific and traditional knowledge. In contrast, the bioregional approach is broader in scope, encompassing not only agriculture but also areas such as tourism development, handicrafts, and the preservation of cultural heritage (Guareschi et al., 2020).

The bioregional approach is based on specific geographic areas by distinct ecological and cultural characteristics (Pezzoli & Leiter, 2016), whereas agroecology can be applied at various scales, independent of territorial boundaries. The concept of bioregions assumes that organic farming and the farmers who practice it play a central role; however, it should be emphasized that a bioregion does not necessarily imply that exclusive use of organic agricultural practices within its territory (Dias et al., 2021). It is important to note that there are also similarities between the two concepts. Both agroecology and the bioregional approach aim to promote sustainable agricultural practices that preserve environmental resources, foster biodiversity, and emphasize the involvement and participation of local communities in decision-making processes, thereby contributing to social cohesion and economic development (Guareschi et al., 2020; Gargano et al., 2021). In bioregions, the promotion of organic products is closely linked to the valorisation of the

territory and its unique attributes, in order to fully realise its economic, social, and cultural potential (Basile, 2014).

Scientific interest in the topic of bioregions has increased alongside their growing popularity in Europe. However, the body of research remains relatively limited and is primarily focused on case studies and comparative analyses (Favilli et al., 2018; Dias et al., 2021; Kraljevic & Zanasi, 2023; Sturla et al., 2024). A number of studies have been dedicated to the classification and identification of bioregions (Zanasi et al., 2020; Guareschi et al., 2020), as well as to the experiences of bioregion implementation.

The definition provided by Harris et al. (2016) 'Bioregions, generally defined as areas that share similar topography, plant and animal life, and human culture, represent an appropriate and consistently applicable scale and framework for sustainable food system analysis, design, and planning', highlights the importance of bioregions in addressing climate change, resource depletion, and environmental degradation, while emphasizing that these regions provide a framework that promotes the sustainability of food systems. In contrast, the definition proposed by Kraljevic & Zanasi (2023): 'Biodistricts, also known as 'organic districts' or 'eco-regions,' are defined as specific geographic areas that integrate organic agriculture with the socio-economic and cultural contexts of their communities', suggests that bioregions are a pragmatic approach to agriculture, based on local needs and cultural values with the aim of supporting local food systems and sustainable agricultural practices. This comprehensive approach aligns with the European Union's initiatives to promote sustainable agricultural development and practice. The EU provides the following definition of a bioregion: 'A 'Bio district' is a geographical area where farmers, the public, tourist operators, associations and public authorities enter into an agreement for the sustainable management of local resources, based on organic principles and practices' (European Commission, 2021).

The application of the bioregional concept in territorial development is illustrated by Stotten and Froning (2023) in their case study of Valposchiavo, Switzerland. They argue that 'biodistricts harness organic agriculture's principles to develop strong local agro-food systems that effectively respond to globalization's impacts, suggesting that a focus on local contexts can facilitate more resilient food systems'. Likewise, Guareschi et al. (2020) define biodistricts as 'local production systems in which organic methods are prevalent but at the same time they are closely connected to other economic, environmental, and socio-cultural elements. This definition highlights that a bioregion operates as a complex network of collaboration, linking organic production with local food systems, entrepreneurship, tourism potential, community involvement, and the preservation of cultural heritage. Such integration fosters a transition towards more sustainable models of agriculture and development, tailored to the specific needs and opportunities of a given territory.

In Latvia, the definition of a bioregion can be found in Cabinet Order No. 238 (2024) 'On the Implementation Plan for the Landscape Policy 2024–2027', where a bioregion in a narrower sense is defined as 'a territory where farming is carried out using organic agricultural practices and methods'. The recommendation provided by the authors of this study is incorporated into a broader definition of a bioregion used in these regulations: 'a territory in which representatives of the local public, private, and non-governmental sectors, as a result of a voluntary agreement, create a living space with the aim of preserving and enhancing biological, socio-economic, cultural, and landscape values by implementing farming and consumption practices that respect local biodiversity and balance the interests of stakeholders in local development planning, sustainable use, and management of local resources'.

Bioregional governance is frequently employed in nature conservation and rural development policy. In the study by Guareschi et al. (2020), the focus is on community well-being and the interaction of agricultural production systems, reflecting a functional approach. Rosa et al. (2024) assess the impact of land use on plant species diversity across Europe. Their findings demonstrate how ecological factors can shape administrative decisions regarding land management, underscoring the need for governance systems to account for ecological boundaries in order to foster biodiversity and sustainability. The study by Lamine et al. (2023) examine Italian bioregions and French territorial food projects, with particular attention to how policy initiatives and public engagement can support the transition towards sustainable food systems. Their results highlight the consolidation of organic farming systems and the recognition of local food identities as key factors in policy development processes.

The economic dimension of bioregional agriculture is reflected in its capacity to strengthen the local economy. By promoting short food supply chains, bioregions enhance local producers' access to market and reduce dependence on larger, often less sustainable, agricultural systems (Guareschi et al., 2020; Kraljevic & Zanasi, 2023). Consequently, localized production systems may prove more profitable, enabling farmers to capture greater value from their products while stimulating regional economic growth and entrepreneurship (Cato, 2011). Furthermore, there is a growing shift towards high-value product markets, such as organic and health-oriented foods, which not only generate higher returns for farmers but also fosters regional identity through gastronomy (Lamine et al., 2023). Simultaneously, Platis et al. (2019) emphasize the reduction of greenhouse gas emissions due to the use of local

resources and shorter transport distances. Support for small and medium-sized farms is another essential aspect of the bioregional strategy, as it reduces competitive pressure from large-scale industrial agriculture, allowing for a more equitable agricultural landscape (Guareschi et al., 2022). By establishing inclusive frameworks that prioritize local agricultural development, bioregions have the potential to reduce economic disparities and enhance community resilience (Stotten & Froning, 2023).

Within the framework of social sustainability, the bioregional approach highlights the importance of community cohesion and local participation in agricultural practices. Engagement in local food initiatives strengthens social bonds and fosters a sense of belonging among residents (Stotten et al., 2018). Moreover, bioregions play a critical role in preserving local culture and traditions, promoting societal diversity and ensuring the continuity of agricultural traditions (Zanasi et al., 2020). Access to healthier food through short supply chains not only promotes better nutrition but also improves public health outcomes, aligning with sustainable development goals aimed at enhancing population well-being (Guareschi et al., 2020).

The emergence of bioregions can be interpreted as a direct response to contemporary trends in economic development, driven by a societal aspiration for improved living conditions. Accordingly, bioregions may be defined as local production systems in which organic and agroecological methods are predominant.

Conclusions

1. The integration of the agroecology and bioregion concepts forms a multidimensional, locally grounded model of sustainable agriculture that simultaneously addresses ecological, economic, and social challenges. The findings of this study confirm that agroecology as a scientific, practical, and social approach, offers effective instruments for facilitating the transition towards more environmentally sustainable and socially equitable food production systems.
2. The concept of bioregions, in turn, provides a territorially specific and structured framework for the practical application of agroecological principles, linking agriculture with cultural heritage, tourism, and local economic development. Collaboration within bioregions among community actors, businesses, and local authorities, facilitates the creation of resilient local food systems and enhance regional economic stability.
3. The reviewed literature confirms that this approach not only enhances biodiversity and reduces environmental pressures, but also fosters community participation, strengthens local identity, and creates favourable conditions for strengthening social cohesion in rural areas. Particularly important is the development of short supply chains and support for small-scale farms, which stimulate regional economies and promote a fairer distribution of income among farmers.
4. Future research should prioritise the quantitative assessment of bioregions' impact, including the application of sustainability indicators, as well as analysing mechanisms for community participation to strengthen agroecological initiatives. In this way, bioregions can become an effective tool for transitioning to a more resilient, human and environment oriented model of agricultural development aligned with sustainable development goals at both national and European levels.

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