European Journal of Development Studies
Vol 5 | Issue 6 | November 2025
ISSN 2736-660X

RESEARCH ARTICLE

Bio-Regions as An Innovative Model of Sustainable Rural Development: An Integrative Literature Review

Rui Alexandre Rodrigues Lagoa[1,*], Cristina Amaro da Costa[2,3], Sofia Florença[3], Manuel Tibério[1], and Ramiro Gonçalves[1]

ABSTRACT

The Bio-Regions, whose origin dates back to Italy, constitute an innovative model of rural development anchored in endogenous dynamics, valuing territorial specificities, local social capital and participatory governance mechanisms. Its integrated approach seeks to articulate organic farming, environmental sustainability, community cohesion and proximity circuits.

This study aims to contribute to the scientific and political debate around Bio-Regions, exploring their transformative potential in the context of territorial public policies. Through an integrative literature review, we sought to understand not only the conceptual and practical evolution of the Bio-Regions, but also the implications of their consolidation in different territorial contexts.

The analysis focused on indexed scientific publications and non-conventional specialized literature, collected through professional and academic networks. The selection of contributions was guided by thematic criteria, favoring studies that addressed institutional factors, the mobilization of local actors and the role of public policies in the operationalization of this development model.

The results highlight the decisive role of the institutional dimension in the consolidation of Bio-Regions, underlining the importance of integrated and participatory political strategies. At the same time, significant gaps in scientific production are identified, particularly with regard to the systematic assessment of the economic, social and environmental impacts associated with the implementation of the Bio-Regions.

Keywords: Bio-regions, organic farming, public policies, sustainable rural development.

Submitted: July 02, 2025

Published: November 24, 2025

10.24018/ejdevelop.2025.5.6.428

[1] *University of Trás-os-Montes and Alto Douro, Portugal.*
[2] *Agrarian School of Viseu, Portugal.*
[3] *Centre for Research in Natural Resources, Environment and Society, Portugal.*

* ***Corresponding Author:***
e-mail: ruiarlagoa@gmail.com

1. Introduction

Decades of inadequate management of rural space have resulted in deeply fragile agricultural territories (Horstink *et al*., 2023). This reality puts at risk the sustainability and the very continuity of life in the rural world. Natural factors, such as geographic location, steep terrain, land fragmentation, and limited accessibility, are combined with socioeconomic factors, such as the predominance of family farms and ineffective public policies, contributing to systematic land abandonment (Bai *et al*., 2015; Zavalloni *et al*., 2021).

Widomski and Musz-Pomorska (2023) identify several constraints to rural sustainability: poor access to basic services (including sanitation), anthropogenic pressure on ecosystems, limited access to renewable energy, depopulation, population ageing, adverse economic conditions, and low agricultural productivity. In these territories, especially mountain ones, sustainable agricultural development requires a balance between ecological and economic systems (Cardillo & Cimino, 2022; Salvati *et al*., 2017). This balance depends, to a large extent, on adequate support policies, as Swagemakers *et al*. (2017), by encouraging the transition to multifunctional agriculture, promoting diversified and differentiated products (Rivas & Quintero, 2014).

The urgency of designing and implementing new models of rural development is evident. Inaction or the implementation of inadequate policies can accentuate the negative effects already identified (Marques & Triches, 2022). The literature documents several cases where measures aimed at rural social development have not had an impact on combating depopulation, mainly due to the poor attractiveness of agricultural life and work and unappealing living conditions (Kovalenko *et al*., 2015; Lopes & Mota, 2021).

In this context, Bio-Regions (or Eco-Regions and Biodistricts) are emerging in Italy as a response to these challenges. These propose an alternative model of territorial development, based on three dimensions: social, economic and environmental, and aim to revitalise rural territories, combating phenomena such as population ageing, desertification, unemployment, and abandonment of agricultural activities (Basile *et al*., 2021; Dias *et al*., 2021; Stefanovic & Agbolosoo-Mensah, 2023). The term "Bio" refers to the widespread adoption of organic farming practices, while "District" alludes to the concentration of small and medium-sized enterprises with strong specialization in rural services (Guareschi *et al*., 2020).

Bio-Regions are an integrated approach to territorial management, promoting alliances between farmers, citizens, tour operators, civil society organisations and local authorities (Guccione *et al*., 2024; Schermer, 2006a; Zanasi *et al*., 2024). This model is based on the principles of organic farming, oriented towards the valorization of local resources and sustainable economic and socio-cultural development (Assiri *et al*., 2020; Paoletti *et al*., 2024; Schermer, 2006b; Stotten *et al*., 2018; Sturla *et al*., 2020). According to Basile (2017), Bio-Regions promote an inclusive, fair development model adapted to current and future challenges, recognizing traditional knowledge, regional varieties, indigenous breeds and short marketing circuits, essential factors for resilience, especially in mountain territories (Ruiz *et al*., 2024). It can be defined as a multifaceted project rooted locally, with the involvement of producers, associations, institutions and local authorities (Cesaro, 2018; Mazzocchi *et al*., 2021; Proskina *et al*., 2023).

Bio-Regions are effective instruments for sustainable territorial development. Its multifunctionality makes it possible to strengthen the attractiveness of rural territories, generate new job opportunities (agricultural and non-agricultural) and counteract the rural exodus (Scaramuzzi *et al*., 2020; Sturla *et al*., 2024). Organic farming, by allowing the differentiation of products and the preservation of ecosystems, can play a strategic role in rural development (Belliggiano *et al*., 2020; Ferreira *et al*., 2020; Schader *et al*., 2021). However, this model requires consistent institutional support, given the technical complexity of the biological system compared to the conventional one. This increased difficulty leads to products with organic certification being scarce in the market (Sturla *et al*., 2018).

The holistic vision of Bio-Regions promotes not only sustainable agricultural practices, but also education and awareness on the interconnection between agriculture and sustainable development, fostering learning and cooperation networks between the various territorial actors (Ruiz *et al*., 2024). Rivas and Quintero (2014) highlight the role of short marketing circuits in the valorization of local products, free of Genetically Modified Organisms (GMOs), within the logic of "kilometer zero". Despite the barriers, such as information asymmetry (Caldeira *et al*., 2017), the social proximity typical of Bio-Regions tends to mitigate these difficulties (Xue *et al*., 2019). The inclusion of local producers in public procurement is also noteworthy, reinforcing the integration between agricultural and food policies (Allen *et al*., 2019; Favilli *et al*., 2018; Kraljevic & Zanasi, 2023; Rittirong *et al*., 2024; Zanasi & Di Fiore, 2018). Di Veroli *et al*. (2024), warn that food waste is lower in Bio-Regions, where public policies encourage the consumption of seasonal and local products (Vargas *et al*., 2021).

The central objective of the Bio-Regions is to contribute to a healthy and sustainable food system, based on territorial diversity and identity. For this, the development of green public policies and effective governance involving local institutions, consumers, producers and research centers is essential (Barca, 2009; Chiappino & Toccaceli, 2013; Guareschi *et al*., 2020; Swagemakers *et al*., 2017). Local authorities play a decisive role in promoting the consumption of local products in public institutions, tourist and social establishments, contributing to the enhancement of the territory (Dias *et al*., 2021).

In view of the above, it is imperative to provide policymakers with accurate and up-to-date information on Bio-Regions, which supports the formulation of public policies appropriate to the specificities of low-density rural territories. This is, therefore, the main objective of the present work. In this context, the central question that guides this study is: how Bio-Regions can contribute to a sustainable rural development model, considering the institutional, social, economic and environmental factors involved.

In line with these objectives, the study is guided by four interrelated research questions: How are Bio-Regions defined and operationalized in different contexts and which institutional features are most salient; What are the factors driving the reported rural decline and what policy or practical solutions are proposed within the Bio-Regions; What evidence exists on the social, economic and environmental outcomes associated with Bio-Regions (or related territorial initiatives); And finally, how Bio-Regions

TABLE I: Inclusion and Exclusion Criteria Applied

Inclusion criteria	Exclusion criteria
Studies published from 2009 onwards	Studies published before 2009
In Spanish, English, Italian and Portuguese	Documents in different languages
Document type-article	All documentation that is not an article
Free access	No access

compare conceptually and operationally with other territorial development approaches, such as LEADER or territorial food projects.

Bio-Regions—also called ecoregions or biodistricts—are participatory and local arrangements that align organic/agroecological farming, short food supply chains, and environmental management within a territorial governance platform. Shared characteristics include: (i) a commitment to organic/agroecological principles; (ii) territorial identity and, sometimes, labeling systems; (iii) multi-actor governance involving producers, consumers and public authorities; and (iv) policy alignment (e.g., sustainable public procurement, education).

In this review, we used the term Bio-Regions to encompass closely related labels that operate on rural development and sustainable food systems—distinct from ecological uses of "ecoregion". Instruments reported in all experiences include support for organic conversion, participatory assurance systems, technical assistance, short food supply chains and local markets, territorial labelling and capacity building.

2. Methodology

This study is based on an integrative literature review, with the aim of collecting, reflecting and synthesizing the available knowledge on Bio-Regions as a sustainable rural development strategy. This methodological approach allows the incorporation not only of indexed scientific studies, but also of specialized sources and unconventional contributions, respecting the complexity and emerging nature of the topic.

2.1. Data Sources and Research Strategy

The bibliographic search was carried out between June and July 2024, focusing on scientific articles published and indexed in the Scopus, Web of Science, and SciELO databases. The selection of publications was peer-validated, ensuring the thematic relevance and methodological quality of the included studies.

Two complementary research strategies were applied sequentially. The first, held on June 18, 2024, was carried out using a search key that incorporated keywords from the theme:

((biodistrict* OR biodistrict* OR ecoregion* OR agroterritorial* OR ecoregion*) AND ("rural development") AND (governance OR policy OR policies)).

In view of the reduced number of relevant results, a second survey was conducted on July 8, 2024, with a broader focus:

(biodistrict* OR biodistrict* OR ecoregion OR agroterritorial* OR ecoregion*).

The deliberate inclusion of the term "ecoregion" aimed to broaden the spectrum of research, recognizing that this concept is often used in areas such as ecology and nature conservation (Edler *et al*., 2017; Omernik & Bailey, 1997; Wang *et al*., 2015). Thus, titles and abstracts were screened, eliminating studies that were not aligned with the research objectives. Eligible articles were subsequently evaluated in full by two independent reviewers.

2.2. Selection and Exclusion Criteria

The selection of studies followed a systematic protocol based on previously defined inclusion and exclusion criteria, with the objective of ensuring the thematic coherence and scientific robustness of the selected articles.

Initially, the articles found in the databases were screened by applying filters such as year, language, type of document, and free access, as shown in the following table (Table I).

After the initial screening, the full texts of the documents that met the inclusion criteria (175 and 7426, in the first and second searches, respectively) were downloaded, as shown in the first half of Table II.

These articles were then submitted to a selection process taking into account the previously established criteria and the scope of the manuscript, proceeding to a careful reading of the titles and abstracts. Articles that did not fit the theme referred to the Ecoregion exclusively in nature conservation works; portrayed public policies that were not related to agriculture/rural development;

TABLE II: RESULTS OF THE LITERATURE SEARCH

	June 18			July 8		
	Scielo	Scopus	Science Web	Scielo	Scopus	Science Web
Search results	4	337	202	500	9251	8345
Date 2009	4	240	181	467	7758	6953
Spanish, English, Italian, Portuguese	4	221	181	467	7629	6936
Article	4	162	145	417	6766	6544
Access allowed	4	92	79	417	3578	3431
Thematic area	2	39	25	258	2568	538
Repeated			14			496
Final			52			2868
After reading in full			49			6

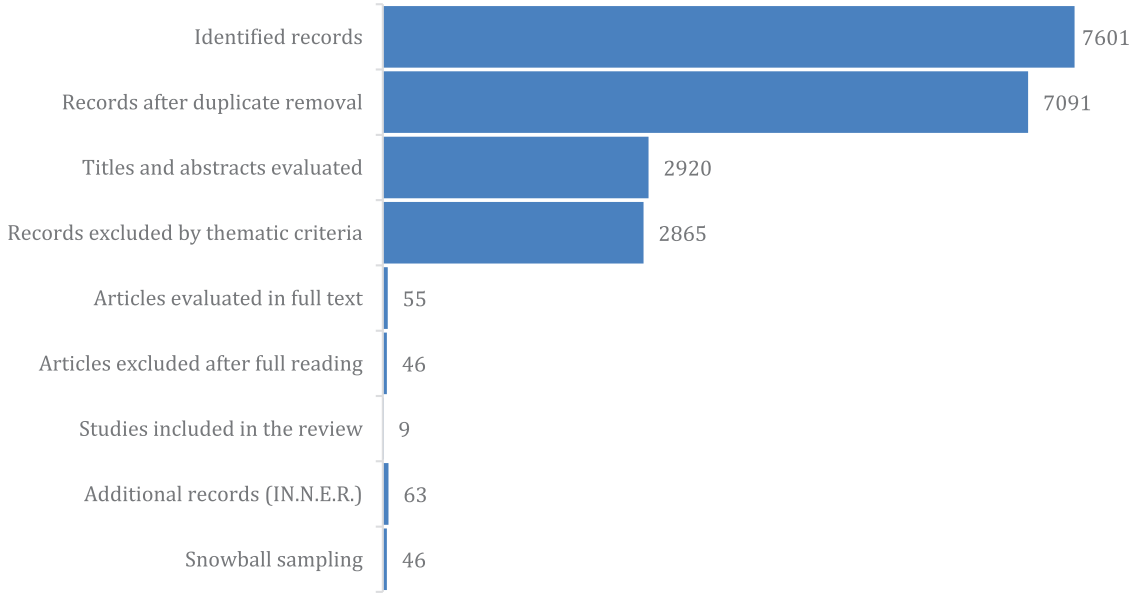

Fig 1. Number of documents per stage of the study selection process.

Rural development not related to territorial dynamics was mentioned. The duplicate articles were then deleted (510), which resulted in the end of 2920 articles.

Next, a full reading of the 2920 articles was performed, where the previously established criteria were again applied, resulting in 55 articles (Table II).

Finally, we kept only the articles that directly addressed the Bio-Regions and their dynamics, eliminating all the articles that simply referred to topics such as ecology or nature conservation. With this beautiful selection, only 9 works worked.

In order to make the process more transparent and facilitate the understanding of the stages and results of the bibliographic searches, the number of documents evaluated in each stage of the study selection process is presented below (Fig. 1).

2.3. - Complementation with Specialized Literature

Recognizing the limitations of the indexed scientific literature on the subject, an additional data collection strategy was adopted through direct contact with members of the IN.N.E.R. (International Network of Eco Regions) board of directors. This process allowed access to 63 relevant technical-scientific and institutional publications provided by experts such as Cesar Zanasi, Emilio Buonomo and Salvatore Basile.

Of the 72 studies initially selected, 9 indexed articles and 63 additional studies obtained from alternative sources, a snowball sampling strategy was used, allowing the analysis to be extended to a total of 118 relevant studies.

For a better understanding of the above, the following figure (Fig. 2) presents a flowchart with the stages of study selection.

Fig. 2 summarizes in a schematic way all the stages of bibliographic screening. The flowchart follows the PRISMA (Preferred Reporting Items for Systematic Reviews) logic (Sarkis-Onofre *et al*., 2021),

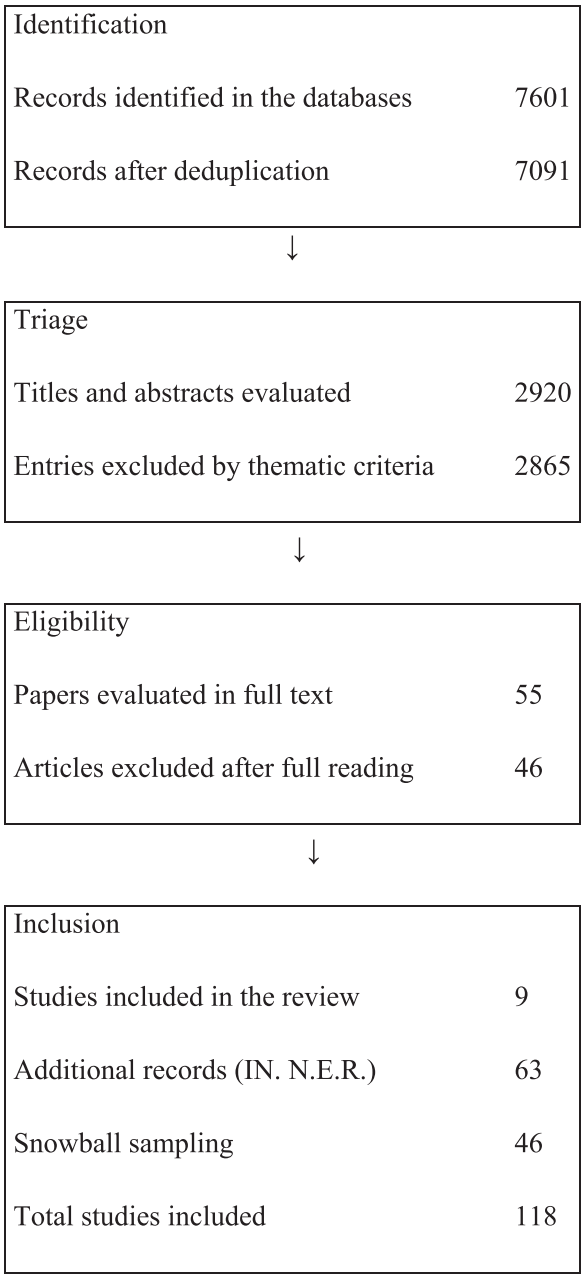

Fig 2. Flowchart with the study selection steps.

allowing the reader to clearly understand the progression from the initial identification of the records to the final inclusion of the selected articles.

All stages of the selection and application of the inclusion and exclusion criteria are documented and follow the principles of transparency and rigor typical of an integrative literature review.

3. Results and Discussion

Agriculture, as a fundamental economic activity, requires special attention to its profitability to ensure the sustainability of rural territories (Belliggiano *et al*., 2020) emphasize that understanding agricultural yield implies the search for alternatives to conventional agriculture, especially in marginal rural areas, impacted by globalization. Rivas and Quintero (2014) underline that twentieth-century industrial agriculture adopted a productivist and reductionist approach, often neglecting crucial ecological and cultural dimensions.

Bio-Regions in Italy were first established within a context of strong organic agriculture movements and local administrations seeking integrated territorial strategies. Common features include a formalized coordination body, the involvement of municipalities and producer associations, and the articulation of actions across production (organic conversion and certification support), markets

TABLE III: Main Reasons Given for Rural Abandonment

Motivate	Number of references
Fires	9
Conventional agriculture	19
Climate change	22
Low productivity	24
Lack of knowledge	29
Lack of performance	31

TABLE IV: Solutions for Rural Development

Solutions	Number of references
Quality certification	14
Forest products	17
Social economy	19
Tourism	23
Multifunctional agriculture	28
Short marketing channels	28
Policies	31
Bio-Region	33
Agroecology	35
Organic farming	37

(short food supply chains, farmers' markets, public procurement for schools), and identity (territorial labelling and tourism links). Italian cases typically operate through multi-actor agreements and are embedded in regional policy frameworks, which helps reduce fragmentation and sustain initiatives through political cycles. Reported effects concern improved coordination among small producers, enhanced local market access, educational initiatives on healthy diets, and environmental practices aligned with organic/agroecological principles. However, limitations remain: administrative capacity varies across municipalities; the evidence on measurable socio-economic outcomes remains uneven; and initiatives rely on stable governance and technical support to avoid dependence on short-term projects.

Taken together, Italian Bio-Regions illustrate a relatively mature governance architecture—multi-actor coordination, policy alignment and territorial labelling—alongside uneven reporting on measurable outcomes. Closing this parenthesis, we now return to the cross-case synthesis: drawing on all 118 sources, we summarise the recurrent drivers of rural decline and the instruments and governance arrangements most frequently reported across contexts (see Table III).

In the northern interior of Portugal, the rural exodus continues to be a worrying phenomenon, influenced by multiple factors. The analysis of the 118 scientific studies included in this review revealed that 35 of them directly address rural abandonment, identifying the main reasons, as shown in the following table (Table III).

Among the factors highlighted, forest fires emerge as one of the most severe impacts of territorial abandonment, with relevant socioeconomic and environmental consequences (Casau *et al*., 2022). Wu *et al*. (2022) associate the higher incidence of fires with climate change, emphasizing the vulnerability of the Mediterranean to global warming (Stocker, 2014). In this context, efficient management of forest residues and biomass as well as active prevention strategies are essential.

Lack of knowledge, the second most cited reason, is also pointed out as an obstacle to rural development. Basile (2019) suggest the creation of regional rural development centers that foster collaborative networks between universities, companies, administrations and local communities.

The main cause identified for rural abandonment was lack of income. This stems from multiple factors: low levels of innovation, low productivity, insufficient technical knowledge, as well as difficulties in addressing challenges such as environmental degradation and climate change (Di Veroli *et al*., 2024; Iakovidis *et al*., 2024).

To counteract these trends, and after analysis of the 118 articles included in the review, 54 of them were identified as a consistent set of proposed solutions for the revitalization of the rural world, as summarized in the following table (Table IV):

The most frequently proposed solutions combine institutional innovation, sustainable practices and the enhancement of local specificities. Quality certification, such as PDO, has been shown to strengthen short supply chains and provide added value to local products (Camanzi *et al*., 2018). Non-timber forest products also stand out as dynamic elements of the rural economy (Schunko *et al*., 2019).

Social and solidarity economy strategies demonstrate effectiveness in promoting community cohesion and territorial equity (do Nascimento *et al*., 2020). The articulation between agriculture and tourism, through agritourism, generates new sources of income and reinforces the link between territorial identity and economic sustainability (Badulescu & Badulescu, 2017; Grillini *et al*., 2023).

Kovalenko *et al*. (2015) and Pugliese and Antonelli (2015) state that the multifunctionality of agriculture represents an integrated approach, which includes certifications, agritourism, environmental education and diversified production. Rudnicki *et al*. (2023) and Mengistu and Belda (2024) underline that this model not only improves the viability of farms but also contributes to territorial cohesion. Assiri *et al*. (2020) emphasise the role of organic farming in economic diversification and territorial aggregation, contributing to rural and local development (Cardillo *et al*., 2023; Danylenko *et al*., 2019; Weltin *et al*., 2017). It has also been shown to be beneficial for environmental quality (Basile & Cecchi, 2001; Bertoni *et al*., 2020; Wiśniewski *et al*., 2021; Pancino *et al*., 2009; Pugliese *et al*., 2023).

The development of short marketing circuits is of particular relevance, promoting direct relationships between producers and consumers and encouraging healthy and sustainable food practices (Al-Masri Aoudi *et al*., 2022).

Among the most mentioned solutions, the Bio-Regions model stands out. Emerged in Italy in 2004, they propose a territorial development model that integrates organic agriculture, participatory governance, and valorization of endogenous resources (Dias *et al*., 2021; Guareschi *et al*., 2020). This model, currently expanded through networks such as the International Network of Ecoregions (IN.N.E.R.) and the Global Alliance for Organic Districts (GOAD), articulated with the principles of agroecology (Basile *et al*., 2021; Gargano *et al*., 2021; IN.N.E.R., 2017; Wezel *et al*., 2018), involving various organizations and promoting intercontinental cooperation (Cuoco & Salvatore, 2014; IFOAM, 2020, 2022).

Despite the transformative potential of Bio-Regions, the data indicate that systematized knowledge about their concrete impacts is still scarce (Gagliardi *et al*., 2014; Packer & Zanasi, 2023). Of the 118 articles analyzed, 44 report positive results, but point to the need for greater rigor in the empirical evaluation of territorial, environmental, and social effects.

Companies located in Bio-Regions tend to have higher human capital, higher investment, and better economic margins (Truant *et al*., 2019). Ferreira *et al*. (2020) and Luczka *et al.* (2021) show that organic farming, even with higher technical requirements, provides more favourable economic outcomes than conventional farming. Organic farming also suffers positive discrimination in EU economic support, however, several authors refer to the lack of efficiency in the distribution of this support. Luczka *et al*. (2021) and Pugliese *et al*. (2023), noted that financial support for organic farming focuses primarily on quantitative growth rather than on stimulating product supply.

The challenges faced by Bio-Regions include the scarcity of local products, the difficulty of integration into public procurement systems, and the resilience of conventional markets (Jouzi *et al*., 2017; Risku-Norja & Løes, 2017; Sonnino, 2009). The inclusion of organic foods in school canteens (ICLEI, 2022a, 2022b; ICLEI & IFOAM, (2021); European Union, 2018, 2023), however, has generated positive impacts on the awareness of teachers, students and families (Kraljevic & Zanasi, 2023; Wahlen *et al*., 2012).

The growing demand for organic products, driven by consumers who are increasingly attentive to health and environmental sustainability, has favored the diversification of agricultural production and the strengthening of local economies. These dynamics have motivated the European Union to establish a set of specific legislation on the subject (European Union, 2014, 2016, 2018, 2021). In this context, territorial labelling and designations of origin stand out as particularly effective strategies to add value and ensure the authenticity of products (González De Molina & Lopez-Garcia, 2021).

The spread of organic farming is also associated with nutritional and public health gains, as pointed out by Yokphonchanachai *et al*. (2023). Good European examples include the Mühlviertel Bioregion in Austria (Furtschegger & Schermer, 2015; Schermer, 2006a) and the Drôme Valley (France), with high conversion rates for organic production (Bui & Lamine, 2015).

The involvement of Bio-Regions in education and technical training is another strategic axis, as evidenced by initiatives such as the "Teaching to produce differently" plan in France (Iakovidis *et al*., 2024; Schnyder, 2023).

In the field of public policies, organic agriculture stands out as an effective instrument in reducing greenhouse gas emissions, as well as in promoting short supply chains (Chiriacó *et al*., 2022; European Commission, 2021; Theurl *et al*., 2014).

The specialized literature is abundant in highlighting the role of "green" policies as fundamental and robust pillars in the promotion of rural development (Oliveira, 2013; Schunko *et al*., 2019). Kovalenko *et al*., (2015) point out that public policies play a crucial role in the management of natural resources, as they act as a long-term guarantee of sustainable interactions between humans and the environment. Badulescu and Badulescu (2017) state that spatial planning policies benefit significantly

TABLE V: Policies to Respond to Rural Abandonment

Motivate	Number of references
Fires	2
Climate change	6
Low productivity	6
Conventional agriculture	8
Lack of knowledge	11
Lack of performance	12

TABLE VI: Policies that Respond to Rural Development

Solutions	Number of references
Forest products	1
Social economy	2
Quality certification	3
Multifunctional agriculture	6
Tourism	11
Agroecology	12
Bio-Region	14
Organic farming	14
Short marketing channels	15

from a deep understanding of the relationships between local communities and the environment that surrounds them.

Assiri *et al*. (2020) reinforce the importance of supporting smallholder farms, which are essential for sustainability, food security and climate change mitigation, such as meeting carbon emission reduction targets (Wang *et al*., 2024), highlighting the role of public aid in the income formation of these farms.

Aware of the relevance of public policies for rural development, we focus our analysis on the actions promoted by political decision-makers that contributed to mitigate the rural exodus. It was found that this theme is addressed in 45 studies, organized according to the reasons presented in Table V:

The measures pointed out aim to strengthen incomes, enhance endogenous potential, promote agricultural modernization, training and organization of farmers, in addition to simplifying market access, in line with sustainable rural development strategies (Salvia *et al*., 2019; Slocum & Everett, 2010).

The expansion of Bio-Regions, particularly in the European Union, has been influenced by a growing alignment with the UN Sustainable Development Goals (AGENDA 2030; Basile, 2019) and with European environmental policies, such as the European Green Deal and the "farm to fork" strategy (Dias *et al*., 2021; Poponi *et al*., 2021; Rudnicki *et al*., 2023; United Nations, 2025; Zanasi *et al*., 2020). The classification of Barroso as an Important World Agricultural Heritage System (SIPAM) by FAO exemplifies the international recognition of sustainable local agricultural practices (Almeida, 2019).

Successful policies focus on harnessing local potential, training farmers, simplifying market access and adapting to climate change.

We obtained answers to our question about the policies implemented that correspond to the solutions proposed in the literature for rural development in 26 of the studies analyzed. The breakdown of these works is shown in Table VI:

The most mentioned measures include the creation of local markets, the certification of groups and the supply of organic products in public institutions, especially schools. Harmonisation of approaches to Bio-Regions is desirable, but it must respect local specificities, ensuring an adapted and co-constructed strategy.

Despite the rigor of the integrative review carried out, this study has some limitations. First, there is a risk of selection bias, as non-indexed sources were included and limited to Portuguese, English, Spanish and Italian, and may exclude relevant perspectives in other languages. Second, the integrative review methodology involves a certain degree of subjective interpretation in the synthesis of results from different types of studies. Third, there was a lack of systematic empirical data on the social, economic and environmental impacts of the Bio-Regions, which limits the ability to generalize. Finally, although we did an additional search, we did not find more recent studies that added evidence to the body of knowledge already included in this review.

4. Conclusions

This study, based on an integrative literature review, allowed us to identify that the main cause of rural exodus is the lack of income and knowledge of producers. Bio-Regions, agroecology and organic farming emerge as the most effective responses to solve this problem.

Bio-Regions emerge as an innovative and sustainable approach to rural development, especially targeted at less-favoured areas and support for small producers and rural communities. However, it is still insufficient. The few existing studies focus mostly on the dimensions related to organic farming, ignoring other activities and elements that generate positive externalities and contribute to the sustainability of Bio-Regions.

To achieve the objectives of the European Green Deal, namely the reduction of carbon emissions, it is essential to expand agricultural research and technological development, as well as to expand the channels for the dissemination of this technology. The Bio-Regions model proves to be a guarantor of environmental sustainability, although limitations have been identified, such as the insufficiency of products that hinders the creation of efficient distribution chains, reducing the effectiveness of collective actions. In addition, there is a lack of coordinated action that integrates the tourism production chain with agriculture.

Several case studies indicate that efforts to implement Bio-Regions contribute significantly to the economic and social aspects of regional development, allowing the active participation of farmers in this process. It should be noted that, unlike conventional agriculture, organic farming and agroecology—directly linked to Bio-Regions—require a longer time horizon for agronomic management, which can impact profitability.

The economic sustainability of farms can be ensured through income diversification strategies, especially among young households adopting Organic Production.

Bio-Regions represent a concrete example of the development of sustainable food systems. Food waste in these regions is lower than in other areas, as a result of public policies that encourage the consumption of seasonal and local products. These initiatives promote the revitalization of rural territories and communities, currently threatened by the rural exodus.

There is an urgent need for an efficient assessment of the social impacts of the Bio-Regions. To this end, it is extremely important to carry out population surveys to assess the perception of changes in local development and the role of the authorities in this process, although current studies focus mainly on improving the living conditions of the inhabitants.

Currently, we face significant challenges of sustainability and reduction of social inequalities. Innovative territorial development represents both a challenge and an opportunity for policymakers to put in place governance mechanisms to support this process. Bio-Regions can inspire new policy strategies at higher levels, with actions adapted to local realities.

"Green policies" are needed that promote the diversification of production on farms and in local food systems. Bio-Regions need local management and governance instruments, in addition to compliance with legal requirements, essential factors for the settlement of populations in rural territories. However, isolated public policies do not guarantee success, and the proactivity of local actors is essential.

The Bio-Regions present diverse realities, with different challenges, partnerships and training and dissemination actions. However, they all share support for organic farming and promote forms of governance at the service of local development, with participatory processes "from the bottom up".

The analysis concludes that the Bio-Regions model has significant potential for the renewal of rural development policies, provided that it is supported by sound public policies, training networks and systematic impact assessments.

It is hoped that the data from this study can influence the current political environment, stimulating the creation of public policies aimed at action and the empowerment of community actors to face the challenges identified.

In short, Bio-Regions, as a model of rural development based on agroecology and organic farming, are positioned as engines for strengthening sustainable food systems. The active mobilization of local actors, fostered by political decision-makers, who promote cooperation between educational institutions, companies, consumers and producers, stands out. However, there is still no solid and updated survey of the policies that contribute to the mitigation of the rural exodus and the problems pointed out in this study in the context of sustainable rural development based on Bio-Regions.

In addition to these conclusions, we also point out that future pilot programmes and systematic empirical studies are needed to assess more accurately the economic, social and environmental impacts of Bio-Regions. Applied research can offer useful tools for policy makers and local communities, strengthening the ability to generalize evidence.

Acknowledgment

The authors thank the Portuguese Foundation for Science and Technology (FCT) for the financial support to the Research Centre for Natural Resources, Environment and Society—CERNAS (UIDB/00681; DOI: 10.54499/UIDP/00681/2020).

Conflict of Interest

The authors declare that they do not have any conflict of interest.

References

Allen, T., Prosperi, P., Cogill, B., Padilla, M., & Peri, I. (2019). A Delphi approach to develop sustainable food system metrics. *Social Indicators Research*, *141*, 1307–1339. https://doi.org/10.1007/s11205-018-1865-8.

Al-Masri Aoudi, R., Charhbili, M., Cros, S., & Baron, M. (2022, July 29–June 1). Consumers relationship with short food supply chain and proximity [Conference session]. *IEEE 6th International Conference on Logistics Operations Management*, Strasbourg, France. https://doi.org/10.1109/GOL53975.2022.9820418

Almeida, A. (2019). *A iniciativa "Sistemas Importantes do Património Agrícola Mundial (SIPAM/GIAHS)" como estratégia de preservação dinâmica de património: estudo de caso do sistema agro-silvo-pastoril do Barroso*. Master's Dissertation in Development Studies. Faculty of Social Sciences and Humanities. University Institute of Lisbon.

Assiri, M., Barone, V., & Silvestri, F. (2020). Planning sustainable development of local productive systems: A methodological approach for the analytical identification of *Ecoregions*. *Journal of Cleaner Production*, *287*, 125006. https://doi.org/10.1016/j.jclepro.2020.125006.

Badulescu, D., & Badulescu, A. (2017). Rural tourism development through cross-border cooperation. The case of Romanian-Hungarian cross-border area. *Eastern Europe Countryside*, *23*(1), 191–208. https://doi.org/10.1515/eec-2017-0009.

Bai, X., Yan, H., Pan, L., & Huang, H. Q. (2015). Multi-agent modeling and simulation of farmland use change in a farming-pastoral zone: A case study of Qianjingou town in inner Mongolia, China. *Sustainability*, *7*(11), 14802–14833. https://doi.org/10.3390/su71114802.

Barca, F. (2009). Un'agenda per la riforma della politica di coesione. Una politica di sviluppo rivolta ai luoghi per rispondere alle sfide e alle aspettative dell'Unione Europea [Independent report]. https://www.unisalento.it/documents/20152/837001/Rapporto+Barca+politica+di+coesione.pdf/a6b3dc6b-9002-ca3d-f7c3-6fbd2121c229?version=1.0.

Basile, E., & Cecchi, C. (2001). Le radici locali della ruralità. In E. Basile, & C. Cecchi (Eds.), *La trasformazione post-industriale della campagna: Dall'agricoltura ai sistemi locali rurali*. Rosenberg & Sellier.

Basile, S. (2019, April 3–5). Agroecology for inclusive territorial development [Conference session]. *Proceedings of the Second FAO International Symposium Scaling up agroecology to achieve the Sustainable Development Goals*, Rome. https://openknowledge.fao.org/server/api/core/bitstreams/1afbfe13-01f6-4957-a6e7-92b57dd25e93/content

Basile, S. (2017). *The experience of the Bio-districts in Italy*. International Network of Ecoregions (IN. N.E.R.). http://www.fao.org/3/a-bt402e.pdf.

Basile, S., Buonomo, E., Basile, R., Latiri-Otthoffer, L., Viel, J.-A., Chapron, C., Lamere, E., Cohen, S., Ferreira, J., Ramos, M., Rogers, A. C., Leirana, D. C., Llinàs, N. F., Romero, L. M., & Latorre, S. S. (2021). *Comparative Analysis on Organic Districts (or Eco-Regions or Bio-Districts) in Europe*. Projet EduEcoRegions Report, Cilento. https://www.ecoregion.info/wp-content/uploads/2021/11/O1-A1_Organic_Districts_in_Europe.pdf.

Belliggiano, A., Sturla, A., Vassallo, M., & Viganò, L. (2020). Neo-endogenous rural development in favor of organic farming: Two case studies from Italian fragile areas. *European Countryside*, *12*(1), 1–29. https://doi.org/10.2478/euco-2020-0001.

Bertoni, D., Curzi, D., Aletti, G., & Olper, A. (2020). Estimating the effects of agri-environmental measures using difference-in-difference coarsened exact matching. *Food Policy*, *90*, 101790. https://doi.org/10.1016/j.foodpol.2019.101790.

Bui, S., & Lamine, C. (2015). *Full report of the Biovallée–France. HealthyGrowth from niche to volume with integrity and confidence*. INRA Ecodéveloppement. https://projects.au.dk/fileadmin/projects/healthygrowth/Case_Study_reports/France_Biovallee_public_version_V250615.pdf.

Caldeira, S., Storcksdieck Genannt Bonsmann, S., Bakogianni, I., Gauci, C., Calleja, A., & Furtado, A. (2017). *Public Procurement of Food for Health: Technical Report on the School Setting*. Luxembourg: Publications Office of the European Union. https://data.europa.eu/doi/10.2760/269508.

Camanzi, L., Arba, E., Rota, C., Zanasi, C., & Malorgio, G. (2018). A structural equation modeling analysis of relational governance and economic performance in agri-food supply chains: Evidence from the dairy sheep industry in Sardinia (Italy). *Agricultural and Food Economics*, *6*(4), 21. https://doi.org/10.1186/s40100-018-0099-z.

Cardillo, C., & Cimino, O. (2022). Small farms in Italy: What is their impact on the sustainability of rural areas? *Land*, *11*(12), 2142. https://doi.org/10.3390/land11122142.

Cardillo, C., Cimino, O., De Rosa, M., & Francescone, M. (2023). The evolution of multifunctional agriculture in Italy. *Sustainability*, *15*(14), 11403. https://doi.org/10.3390/su151411403.

Casau, M., Dias, M. F., Teixeira, L., Matias, J. C. O., & Nunes, L. J. R. (2022). Reducing rural Fire risk through the development of a sustainable supply chain model for residual agroforestry biomass supported in a web platform: A case study in portugal central region with the project BioAgroFloRes. *Fire*, *5*(3), 61. https://doi.org/10.3390/fire5030061.

Cesaro, S. (2018). *La experiencia de los bio-distritos: el ejemplo del Bio-Distretto Cilento y las oportunidades para los territorios de la Comunidad Valenciana*. Trabajo de Máster en Desarrollo Local e Innovacion Territorial, University of Alicante.

Chiappino, S., & Toccaceli, D. (2013). The relevance of district contexts in the utilization of rural development policies: Experience from Italy. *International Agricultural Policy*, *4*, 33–45. https://ageconsearch.umn.edu/record/190606/files/3.pdf.

Chiriacó, M. V., Castaldi, S., & Valentini, R. (2022). Determining organic versus conventional food emissions to foster the transition to sustainable food systems and diets: Insights from a systematic review. *Journal of Cleaner Production*, *380*(2), 134937. https://doi.org/10.1016/j.jclepro.2022.134937.

Cuoco, E., & Salvatore, B. (2014, October 13–15). *Bio-Districts to boost organic production* [Conference session]. *Practitioners' Track, IFOAM Organic World Congress 2014, 'Building Organic Bridges'*, Istanbul. Turkey.

Danylenko, A., Sokolska, T., Yukhymenko, P., & Lobunets, V. (2019). Multifunctional agriculture and its effect on rural territories development. *Proceedings of the National Academy of Sciences of Belarus, Agrarian Series*, *57*(3), 277–285. https://doi.org/10.29235/1817-7204-2019-57-3-277-285.

Dias, R. S., Costa, D. V., Correia, H. E., & Costa, C. A. (2021). Building bio-districts or eco-regions: Participative processes supported by focal groups. *Agriculture*, *11*(6), 511. https://doi.org/10.3390/agriculture11060511.

Di Veroli, J. N., Peronti, B., Scognamiglio, U., Baiamonte, I., Paoletti, F., Stefanovic, L., & Rossi, L. (2024). Food waste behaviors of the families of the Cilento Bio-District in comparison with the national data: Elements for policy actions. *Frontiers in Sustainable Food Systems*, *8*, 1385700. https://doi.org/10.3389/fsufs.2024.1385700.

do Nascimento, F. S., Calle-Collado, Á., & Muñoz Benito, R. (2020). Economía social y solidaria y agroecología en cooperativas de agricultura familiar en Brasil como forma de desarrollo de una agricultura sostenible. *Revista de Economía Pública, Social y Cooperativa*, *98*, 189–211. https://doi.org/10.7203/CIRIEC-E.98.14161.

Edler, D., Guedes, T., Zizka, A., Rosvall, M., & Antonelli, A. (2017). Infomap bioregions: Interactive mapping of biogeographical regions from species distributions. *Systematic Biology*, *66*(2), 197–204.

European Commission. (2021). *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions on an action plan for the development of organic production*. COM(2021) 141 final, Brussels, 25.3.2021. https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52021DC0141.

European Union. (2014). *Directive 2014/24/EU of the European Parliament and of the Council of 26 February 2014 on public procurement and repealing Directive 2004/18/EC*. Official Journal of the European Union, L 94/65, 28.3.2014. https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:.

European Union. (2016). *Consolidated Version of the Treaty on European Union*. Official Journal of the European Union, C326/13, 26.10.2012. https://eur-lex.europa.eu/resource.html?uri=cellar:2bf140bf-a3f8-4ab2-b506-fd71826e6da6.0023.02/DOC_1&format=PDF.

European Union. (2018). *Regulation (Eu) 2018/848 of the European Parliament and of the Council of 30 May 2018 on organic production and labelling of organic products and repealing Council Regulation (EC) No 834/2007*. Official Journal of the European Union, L150/1, 14.6.2018. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32018R0848.

European Union. (2021, April 19). *Action Plan for Organic Production in the EU*. Brussels, Belgium: Directorate-General for Agriculture and Rural Development. https://agriculture.ec.europa.eu/farming/organic-farming/organic-action-plan.

European Union. (2023). *Green public procurement. Procuring goods, services and works with a reduced environmental impact throughout their life cycle* Directorate-General for Environment, Brussels, Belgium. https://green-forum.ec.europa.eu/green-business/green-public-procurement_en.

Favilli, E., Ndah, T. H., & Barabanova, Y. (2018, July 1–5). Multi-actor interaction and coordination in the development of a territorial innovation project: some insights from the Cilento Bio-district in Italy [Conference session]. *13th European International Farming Systems Association (IFSA) Symposium, Farming systems: facing uncertainties and enhancing opportunities*. vol. *23*. Chania, Crete, Greece, pp. 1–9. https://www.cabidigitallibrary.org/doi/epdf/10.5555/20183360701

Ferreira, S., Oliveira, F., Gomes da Silva, F., Teixeira, M., Gonçalves, M., Eugénio, R., Damásio, H., & Gonçalves, J. M. (2020). Assessment of factors constraining organic farming expansion in Lis Valley, Portugal. *AgriEngineering*, *2*(1), 111–127. https://doi.org/10.3390/agriengineering2010008.

Furtschegger, C., & Schermer, M. (2015). *Bioregion Mühlviertel–Austria–Case Study FactSheet*. Austria: University of Innsbruck. https://orgprints.dk/id/eprint/29236/19/29236a.pdf.

Gagliardi, D., Niglia, F., & Battistella, C. (2014). Evaluation and design of innovation policies in the agro-food sector: An application of multilevel self-regulating agents. *Technological Forecasting and Social Change*, *85*, 40–57. https://doi.org/10.1016/j.techfore.2013.10.015.

Gargano, G., Licciardo, F., Verrascina, M., & Zanetti, B. (2021). The agroecological approach as a model for multifunctional agriculture and farming towards the European Green Deal 2030—some evidence from the Italian experience. *Sustainability*, *13*(4), 2215. https://doi.org/10.3390/su13042215.

González De Molina, M., & Lopez-Garcia, D. (2021). Principles for designing Agroecology-based Local (territorial) Agri-food Systems: A critical revision. *Agroecology and Sustainable Food Systems*, *45*(7), 1050–1082. https://doi.org/10.1080/21683565.2021.1913690.

Grillini, G., Sacchi, G., Streifeneder, T., & Fischer, C. (2023). Differences in sustainability outcomes between agritourism and non-agritourism farms based on robust empirical evidence from the Tyrol/Trentino mountain region. *Journal of Rural Studies*, *104*, 103152.

Guareschi, M., Maccari, M., Sciurano, J. P., Arfini, F., & Pronti, A. (2020). A methodological approach to upscale toward an agroecology system in EU-LAFSs: The case of the parma bio-district. *Sustainability*, *12*(13), 5398. https://doi.org/10.3390/su12135398.

Guccione, G., Vigano, L., Sturla, A., Vaccaro, A., Colombo, L., Pirelli, T., & Varia, F. (2024). Insights into the agroecological transition: The case of two Italian bio-districts. *Italian Review of Agricultural Economics (REA)*, *79*(1), 97–111. https://doi.org/10.36253/rea-14241.

Horstink, L., Schwemmlein, K., & Encarnação, M. F. (2023). Food systems in depressed and contested agro-territories: Participatory Rural Appraisal in Odemira. *Portugal Frontiers in Sustainable Food Systems*, *6*, 1046549. https://doi.org/10.3389/fsufs.2022.1046549.

Iakovidis, D., Gadanakis, Y., Campos-Gonzalez, J., & Park, J. (2024). Optimising decision support tools for the agricultural sector. *Environment, Development and Sustainability*, 1–25. https://doi.org/10.1007/s10668-024-04743-x.

ICLEI, & IFOAM. (2021). *Sustainable public procurement of food: a goal within reach*. ICLEI - Local Governments for Sustainability, IFOAM Organics Europe. https://foodpolicycoalition.eu/wp-content/uploads/2021/06/Sustainable-public-procurement-of-food-a-goal-within-reach_EU-FPC-website.pdf.

ICLEI. (2022a). *Manifesto for the Establishment of Minimum Standards for Public Canteens Across the EU*. Bonn, Germany: ICLEI - Local Governments for Sustainability. https://iclei-europe.org/publicationstools/?c=search&uid=AXvXw6K2.

ICLEI. (2022b). *Report on iNnovative Criteria and Models for Procurement of Sustainable and Healthy School Meals*. Bonn, Germany: ICLEI European Secretariat. https://www.oneplanetnetwork.org/sites/default/files/2025-01/D5.1-Innovative-CriteriaModels-for-Proc-of-SustHealthy-School-Meals.pdf.

IFOAM. (2020). *Principles of Organic Farming*. Bonn, Germany: IFOAM Organics International. https://www.ifoam.bio/sites/default/files/2020-03/poa_english_web.pdf.

IFOAM. (2022). *Participatory Guarantee Systems*. Bonn, Germany: IFOAM Organics International. https://www.ifoam.bio/our-work/how/standards-certification/participatory-guarantee-systems.

IN.N.E.R. (2017). 52 Profiles on Agroecology: The Experience of Biodistricts in Italy. FAO. Gypsies. https://www.fao.org/3/bt402e/bt402e.pdf.

Jouzi, Z., Azadi, H., Taheri, F., Zarafshani, K., Gebrehiwot, K., Van Passel, S., & Lebailly, P. (2017). Organic farming and small-scale farmers: Main opportunities and challenges. *Ecological Economics*, *132*, 144–154. https://doi.org/10.1016/j.ecolecon.2016.10.016.

Kovalenko, E. G., Polushkina, T. M., & Yakimova, O. Y. (2015). The mechanism of the state regulation of sustainable development of rural areas. *Asian Social Science*, *11*(8), 181. https://doi.org/10.5539/ass.v11n8p181.

Kraljevic, B., & Zanasi, C. (2023). Drivers affecting the relation between biodistricts and school meals initiatives: Evidence from the Cilento biodistrict. *Frontiers in Sustainable Food Systems*, *7*, 1235871. https://doi.org/10.3389/fsufs.2023.1235871.

Lopes, R., & Mota, B. (2021). Innovative local policies in Portuguese low-density rural areas. *Innovative Local Policies in Portuguese Low-Density Rural Areas*, *2*, 388–409. https://doi.org/10.2478/euco-2021-0024.

Luczka, W., Kalinowski, S., & Shmygol, N. (2021). Organic farming support policy in a sustainable development context: a polish case study. *Energies*, *14*(14), 4208. https://doi.org/10.3390/EN14144208.

Marques, A. B. G. M., & Triches, R. M. (2022). Aquisição de alimentos orgânicos pelo Programa Nacional de Alimentação Escolar no Paraná. *Revista Desenvolvimento e Meio Ambiente*, *60*, 502–520. https://doi.org/10.5380/dma.v60i0.79120.

Mazzocchi, C., Orsi, L., Bergamelli, C., & Sturla, A. (2021). Bio-districts and the territory: Evidence from a regression approach. *Aestimum*, *79*, 5–23. https://doi.org/10.36253/aestim-12163.

Mengistu, N. A., & Belda, R. H. (2024). The role of livelihood diversification strategies in the total household income in Takusa Woreda, Amhara Region. *Ethiopia Cogent Social Sciences*, *10*(1), 2306033. https://doi.org/10.1080/23311886.2024.2306033.

Oliveira, C. (2013). *Proposta de desenvolvimento de uma estratégia territorial biológico: o caso do bio-distretto e sua aplicação em Portugal*. Master's Degree in Organic Farming, Polytechnic Institute of Viana do Castelo, Ponte de Lima. http://repositorio.ipvc.pt/jspui/handle/20.500.11960/1258?mode=full.

Omernik, J. M., & Bailey, R. G. (1997). Distinguishing between watersheds and ecoregions 1. *JAWRA Journal of the American Water Resources Association*, *33*(5), 935–949. https://doi.org/10.1111/j.1752-1688.1997.tb04115.x.

Packer, G., & Zanasi, C. (2023). Comparing social sustainability assessment indicators and tools for bio-districts: Building an analytical framework. *Frontiers in Sustainable Food Systems*, *7*, 1229505. https://doi.org/10.3389/fsufs.2023.1229505.

Pancino, B., Franco, S., & Marino, D. (2009). Identificazione dei distretti biologici: un approccio metodologico. In M. Crescimanno, G. Schifani (Eds.), *Agricoltura Biologica: sistemi produttivi e modelli di commercializzazione e di Consumo* (pp. 103–109), Università degli Studi di Palermo. https://sebina.iamb.it/sebina/repository/catalogazione/immagini/pdf/Grab-it.pdf

Paoletti, F., Peronti, B., Rossi, L., Scognamiglio, U., Basile, S., El Bilali, H., Pugliese, P., Rota, C., & Zanasi, C. (2024). *Rapporto Caso Studio "Cilento"*. Roma: SySOrg, CREA Alimenti e Nutrizione. https://www.ecoregion.info/wp-content/uploads/2024/11/Rapporto-caso-studio-Cilento-settembre-2024.pdf.

Poponi, S., Arcese, G., Mosconi, E. M., Pacchera, F., Martucci, O., & Elmo, G. C. (2021). Multi-actor governance for a circular economy in the agri-food sector: Bio-districts. *Sustainability*, *13*(9), 4718. https://doi.org/10.3390/su13094718.

Proskina, D., Proskina, L., Pelse, M., Kaufmane, D., Naglis-Liepa, K., & Paula, L. (2023, September 26–28). Bioregions as an approach to sustainable production and consumption [Conference session]. *Proceedings of the 11th International Scientific Conference "Rural Development 2023: Bioeconomy for the Green Deal"*, Kaunas district, Lithuania, pp. 340–344. https://doi.org/10.15544/RD.2023.033

Pugliese, P., & Antonelli, A. (2015). *Full Case Study Report: Bio-Distretto Cilento - Italy*. Rome: CIHEAM, Bari and AIAB. http://orgprints.org/29252/7/29252.pdf.

Pugliese, P., Antonelli, A., Rota, C., Zanasi, C., & Basile, S. (2023). *L'agricoltura biologica in chiave territoriale (WP3). Rapporto finale sull'esperienza dei bio-distretti in Italia*. CIHEAM Bari, Italia. https://www.ecoregion.info/wp-content/uploads/2021/04/DIMECOBIO_WP3_finale.pdf.

Risku-Norja, H., & Løes, A. K. (2017). Organic food in food policy and in public catering: Lessons learned from Finland. *Organic Agriculture*, *7*(2), 111–124. https://doi.org/10.1007/s13165-016-0148-4.

Rittirong, J., Chuenglertsiri, P., Nitnara, P., & Phulkerd, S. (2024). Developing key indicators for sustainable food system: A comprehensive application of stakeholder consultations and Delphi method. *Frontiers in Sustainable Food Systems*, *8*, 1367221. https://doi.org/10.3389/fsufs.2024.1367221.

Rivas, Á., & Quintero, H. (2014). Reappraising the multiple functions of traditional agriculture within the context of building rural development investigative skills. *Agronomía Colombiana*, *32*(1), 130–137. https://doi.org/10.15446/agron.colomb.v32n1.40185.

Rudnicki, R., Biczkowski, M., Wiśniewski, Ł., Wiśniewski, P., Bielski, S., & Marks-Bielska, R. (2023). Towards green agriculture and sustainable development: Pro-environmental activity of farms under the common agricultural policy. *Energies*, *16*(4), 1770. https://doi.org/10.3390/en16041770.

Ruiz, F., Villanueva, A., & Bazile, D. (2024). Choremetic modeling to represent dynamics in the quinoa agroecosystems in Peru. *Plos one*, *19*(4), e0300464. https://doi.org/10.1371/journal.pone.0300464.

Salvati, L., Tombolini, I., Gemmiti, R., Carlucci, M., Bajocco, S., Perini, L., Ferrara, A., & Colantoni, A. (2017). Complexity in action: Untangling latent relationships between land quality, economic structures and socio-spatial patterns in Italy. *PloS One*, *12*(6), e0177853. https://doi.org/10.1371/journal.pone.0177853.

Salvia, R., Egidi, G., Vinci, S., & Salvati, L. (2019). Desertification risk and rural development in Southern Europe: Permanent assessment and implications for sustainable land management and mitigation policies. *Land*, *8*(12), 191. https://doi.org/10.3390/land8120191.

Sarkis-Onofre, R., Catalá-López, F., Aromataris, E., & Lockwood, C. (2021). How to properly use the PRISMA Statement. *Systematic Reviews*, *10*(1), 117. https://doi.org/10.1186/s13643-021-01671-z.

Scaramuzzi, S., Belletti, G., & Biagioni, P. (2020). Integrated supply chain projects and multifunctional local development: The creation of a Perfume Valley in Tuscany. *Agricultural and Food Economics*, *8*(1), 5. https://doi.org/10.1186/s40100-019-0150-8.

Schader, C., Heidenreich, A., Kadzere, I., Egyir, I., Muriuki, A., Bandanaa, J., Clottey, C., Ndungu, J., Grovermann, C., Lazzarini, G., Blockeel, J., Borgemeister, C., Muller, A., Kabi, F., Fiaboe, K., Adamtey, N., Huber, B., Niggli, U., & Stolze, M. (2021). How is organic farming performing agronomically and economically in sub-Saharan Africa? *Global Environmental Change*, *70*, 102325. https://doi.org/10.1016/j.gloenvcha.2021.102325.

Schermer, M. (2006a, May 30–31). A territorial approach to organic farming: the case of eco-regions in Austria [Conference session]. *Joint Organic Congress*, Odense, Denmark. https://orgprints.org/id/eprint/7834

Schermer, M. (2006b). Regional rural development: The formation of ecoregions. *Sociological Perspectives of Organic Agriculture: From Pioneer to Policy*, 227. https://www.cabidigitallibrary.org/doi/10.1079/9781845930387.0227.

Schnyder, M. (2023). The Biovallée biodistrict. In *Global Norms in Local Contexts: Examining Cases of Environmental Governance in France* (pp. 61–72), Cham: Springer International Publishing.

Schunko, C., Lechthaler, S., & Vogl, C. R. (2019). Conceptualising the factors that influence the commercialisation of non-timber forest products: The case of wild plant gathering by organic herb farmers in South Tyrol (Italy). *Sustainability*, *11*(7), 2028. https://doi.org/10.3390/su11072028.

Slocum, S. L., & Everett, S. (2010). Food tourism initiatives: Resistance on the ground. *WIT Transactions on Ecology and the Environment*, *142*, 745–757. https://doi.org/10.2495/SW100671.

Sonnino, R. (2009). Quality food, public procurement, and sustainable development: The school meal revolution in Rome. *Environment and Planning A*, *41*(2), 425–440. https://doi.org/10.1068/a40112.

Stefanovic, L., & Agbolosoo-Mensah, O. A. (2023). Biodistricts as a tool to revitalize rural territories and communities: Insights from the biodistrict Cilento. *Frontiers in Sustainable Food Systems*, *7*, 1267985. https://doi.org/10.3389/fsufs.2023.1267985.

Stocker, T. (Ed.) (2014). *Climate change 2013: The physical science basis: Working Group I contribution to the Fifth assessment report of the Intergovernmental Panel on Climate Change*. Cambridge, UK: Cambridge University Press.

Stotten, R., Bui, S., Pugliese, P., Schermer, M., & Lamine, C. (2018). Organic values-based supply chains as a tool for territorial development: A comparative analysis of three european organic regions. *The International Journal of Sociology of Agriculture and Food*, *24*(1), 135–154. https://doi.org/10.48416/ijsaf.v24i1.120.

Sturla, A., Iacono, R., & Licciardo, F. (2018). Agricoltura biologica e biodistretti. *L'esperienza della Val Camonica 8-Numero*, *8*(3-Maggio), 92. http://www.eyesreg.it/2018/agricoltura-biologica-e-biodistretti-lesperienza-della-val-camonica/.

Sturla, A., Viganò, L., Longhitano, D., Bimbati, B., & Dara, G. G. (2020). *L'agricoltura Biologica Per lo Sviluppo Territoriale-L'esperienza Dei Distretti Biologici*. Rete Rurale Nazionale 2014/2020. https://www.reterurale.it/flex/cm/pages/ServeBLOB.php/L/IT/IDPagina/19806.

Sturla, A., Viganò, L., Vassallo, M., & Belliggiano, A. (2024). Mission, (self)-perception and role in localized food systems of Italian biodistricts: Insights from a Delphi survey. *Frontiers in Sustainable Food Systems*, *8*, 1433261. https://doi.org/10.3389/fsufs.2024.1433261.

Swagemakers, P., Dominguez Garcia, M. D., Onofa Torres, A., Oostindie, H., & Groot, J. C. J. (2017). A values-based approach to exploring synergies between livestock farming and landscape conservation in Galicia (Spain). *Sustainability*, *9*(11), 1987. https://doi.org/10.3390/su9111987.

Theurl, M., Haberl, H., Erb, K. H., & Lindenthal, T. (2014). Contrasted greenhouse gas emissions from local versus long-range tomato production. *Agronomy for Sustainable Development*, *34*(3), 593–602. https://doi.org/10.1007/s13593-013-0171-8.

Truant, E., Broccardo, L., & Zicari, A. (2019). Organic companies' business models: Emerging profiles in Italian bio-districts. *British Food Journal*, *121*(9), 2067–2085. https://doi.org/10.1108/BFJ-03-2019-0158.

United Nations (2025). *Sustainable Development Goals*. United Nations, Washington, DC, United States. https://sustainabledevelopment.un.org/?menu=.

Vargas, A. M., de Moura, A. P., Deliza, R., & Cunha, L. M. (2021). The role of local seasonal foods in enhancing sustainable food consumption: A systematic literature review. *Foods*, *10*(9), 2206. https://doi.org/10.3390/foods10092206.

Wahlen, S., Heiskanen, E., & Aalto, K. (2012). Endorsing sustainable food consumption: Prospects from public catering. *Journal of Consumer Policy*, *35*(1), 7–21. https://doi.org/10.1007/s10603-011-9183-4.

Wang, F., Mu, X., Li, R., Fleskens, L., Stringer, L. C., & Ritsema, C. J. (2015). Co-evolution of soil and water conservation policy and human-environment linkages in the Yellow River Basin since 1949. *Science of the Total Environment*, *508*, 166–177. https://doi.org/10.1016/j.scitotenv.2014.11.055.

Wang, Y., Zhang, T., Wang, X., Jiang, B., & Huang, X. (2024). Impact of technical progress and fiscal support to agriculture on agricultural carbon emissions. *Cogent Food & Agriculture*, *10*(1), 2300186. https://doi.org/10.1080/23311932.2023.2300186.

Weltin, M., Zasada, I., Franke, C., Piorr, A., Raggi, M., & Viaggi, D. (2017). Analysing behavioural differences of farm households: An example of income diversification strategies based on European farm survey data. *Land Use Policy*, *62*, 172–184. https://doi.org/10.1016/j.landusepol.2016.11.041.

Wezel, A., Goette, J., Lagneaux, E., Passuello, G., Reisman, E., Rodier, C., & Turpin, G. (2018). Agroecology in Europe: Research, education, collective action networks, and alternative food systems. *Sustainability*, *10*(4), 1214. https://doi.org/10.3390/su10041214.

Widomski, M. K., & Musz-Pomorska, A. (2023). Sustainable development of rural areas in poland since 2004 in the light of sustainability indicators. *Land*, *12*(2), 508. https://doi.org/10.3390/land1202058.

Wiśniewski, L., Biczkowski, M., & Rudnicki, R. (2021). Natural potential versus rationality of allocation of Common Agriculture Policy funds dedicated for supporting organic farming development–Assessment of spatial suitability: The case of Poland. *Ecological Indicators*, *130*, 108039. https://doi.org/10.1016/j.ecolind.2021.108039.

Wu, Z., Li, M., Wang, B., Tian, Y., Quan, Y., & Liu, J. (2022). Analysis of factors related to forest fires in different forest ecosystems in China. *Forests*, *13*(7), 1021. https://doi.org/10.3390/f13071021.

Xue, Z., Zhen, L., Miah, M. G., & Shoyama, K. (2019). Impact assessment of land use functions on the sustainable regional development of representative Asian countries-A comparative study in Bangladesh, China and Japan. *Science of the Total Environment*, *694*, 133689. https://doi.org/10.1016/j.scitotenv.2019.133689.

Yokphonchanachai, C., Songserm, N., Thongprung, S., Thongchai, C., Paengprakhon, Y., Duangsri, J., & Sriwarom, O. (2023). Capacity building of a self-reliant model community for cholangiocarcinoma prevention by producing fruit and vegetable juice products in a high-risk area of Thailand. *Asian Pacific Journal of Cancer Prevention: APJCP*, *24*(2), 725. https://doi.org/10.31557/APJCP.2023.24.2.725.

Zanasi, C., & Di Fiore, G. (2018). An analytical approach to support urban agriculture policies development: Case study of Barcelona. *2018 International European Forum (163rd EAAE Seminar)*, Innsbruck-Igls, Austria. https://ideas.repec.org/p/ags/iefi18/276873.html

Zanasi, C., Basile, S., Paoletti, F., Pugliese, P., & Rota, C. (2020). Design of a monitoring tool for eco-regions. *Frontiers in Sustainable Food Systems*, *4*, 536392. https://doi.org/10.3389/fsufs.2020.536392.

Zanasi, C., Stefanovic, L., & Strassner, C. (2024). Biodistricts: A concrete example of sustainable food systems. *Frontiers in Sustainable Food Systems*, *8*, 1455713. https://doi.org/10.3389/fsufs.2024.1455713.

Zavalloni, M., D'Alberto, R., Raggi, M., & Viaggi, D. (2021). Farmland abandonment, public goods and the CAP in a marginal area of Italy. *Land Use Policy*, *107*, 104365. https://doi.org/10.1016/j.landusepol.2019.104365.