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Review

Benefits of Organic Agriculture under the Perspective of the Bioeconomy: A Systematic Review

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Abstract: The opportunities for the global growth of the bioeconomy (BE) are generated by the need to expand the food supply for an increasing world population without compromising the environment even further. Organic agriculture (OA) claims to be more environmentally friendly than conventional agriculture and capable of addressing sustainable development objectives by using green technologies, resulting in economic, social, and ecological benefits. The aim of this paper is to investigate the relation between OA and BE through a systematic literature review. We addressed the benefits of OA under perspective of the main aspects of BE. As demonstrated by previous papers assessed on this review, OA can be a means to facilitate strategies for the use of renewable resources to mitigate the emergencies arising from global warming, as claimed by the BE concept. This article introduces a necessary discussion due the lack of previous studies reporting the capacity of OA to connect with the BE. As a final contribution, we present a conceptual framework characterizing potential benefits of OA under the perspective of BE, for organic farmers and researchers to advance in sustainability and green innovation.

Keywords: bioeconomy; organic agriculture; green technology; sustainability

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1. Introduction

The main challenge of the first half of the twenty-first century will be to reinvent current methods of producing food and develop more sustainable approaches that could generate enough food for twice the world population without compromising terrestrial ecosystems; rather, such approaches should contribute to the substantial regulation of the climatic emergencies caused by global warming [1–5].

The factors associated with climate change include expansionist and intensivist agriculture activities, which reduce biodiversity, increase greenhouse gas emissions, and deplete critical ecosystem services, resulting in the land, water, and climate degradation [1,2,6]. The continued development of methods to quickly identify and control abiotic and biotic threats to agriculture is a priority for scientists, whose research will need to build resilience in adapting to climate change and help implement mitigation strategies [7].

The growing environmental problems, mainly resulting from human activities, require the control of production and consumer attitudes to protect natural resources and achieve sustainable development. The use of renewable resources can allow societies to maintain their economic growth while limiting negative impacts on the environment and preserving natural resources. Adapting to a bio-based economy requires a radical change in production patterns, which involves utilizing alternative clean energies and renewable inputs in production processes [8,9].

Since human needs tend to increase but are currently constrained by the necessity of significantly reducing emissions of carbon dioxide into the atmosphere, there is a trend towards a transition to a sustainable BE to help to reduce greenhouse gas emissions and human dependence on non-renewable resources [7]. The development of the BE will be an important determinant of the sustainable agricultural productivity growth required to meet food security goals and to generate jobs and income [10].

The BE promises economic growth and environmental gain through the conversion of renewable biological resources into the food, feed, fuel, chemicals, and fibers of the future [9], establishing the requirement that resources must be used and managed sustainably, while pressures on ecosystems must be minimized [11].

The BE scenario in agriculture results in food security and is capable of minimizing pressure on land and water resources, through advanced technologies may increase resource use efficiency [10]. Principles transformed in practice will be essential to activate sustainable agriculture productivity to meet food security goals [10].

In the same way, OA has common objectives within BE, such as sustainability of food production, minimum environmental impacts with a closed farming system that includes plants and animals to make feasible effective recycling nutrients [12]. Agroecological practices as organic soil management reduce vulnerabilities to climate change, including a diversification in the crop, water conservation, and increase biodiversity rates [13].

Based on how OA and BE concepts seem to be interlinked, this study aims to investigate the relation between OA and BE through a systematic literature review, focusing on recent studies published in the last 10 years, taken from the Scopus database. We highlighted results that point out the benefits of OA under perspective of the BE main aspects.

In this study, we analyzed different authors' positions regarding BE and OA. All the levels of analysis are potentially informative, and the conceptual framework proposed here was developed using these different approaches.

The construction of this study involved the following methods: (1) a systematic literature review of OA and BE from 2010–2020 in the Scopus database; (2) preliminary analysis of the articles evaluating titles and abstracts; (3) construction of analysis identifying the concept and key aspects for the development of BE; (4) identification of benefits from OA that are linked with the BE; (5) developing a conceptual framework that defines the interrelationships between BE aspects and OA benefits.

This work is divided into 5 sections: Section 1 is the introduction. Section 2 describes the systematic process conducted in this review. Section 3 presents our findings about the concept, key-aspects for the development of BE, and evidence of OA benefits aligned with these aspects. Section 4 presents the discussion related to the research question, limitations, and avenues for future research. Finally, Section 5 describes conclusions and future directions.

2. Materials and Methods

The systematic review method was employed to investigate the relation between OA and BE, with emphasis in the benefits of OA under perspective of the main aspects of BE. Systematic reviews differ from traditional narrative reviews by adopting a replicable, scientific, and transparent process that aims to minimize bias through engaging in exhaustive literature searches of published studies and by providing an audit trail of the reviewers' decisions, procedures, and conclusions [14].

As suggested by Sampaio and Mancini [15], the following stages of the systematic literature review were implemented in this research: location and identification of the studies, selection of the studies, analysis, synthesis of the data, and finally, reporting and use of the research results.

2.1. Location and Identification of the Studies

Before beginning the literature review, we defined the search criterion, namely journal articles published in English, with high impact factors. Articles from 2010 to 2020 were considered for analysis to avoid older empirical studies that may have been superseded by more recent findings. This period also coincides with a large number of political programs—documents developed in the European Commission, and the publication of the European White Paper of the Bioeconomy [16]. The database searched was Scopus, which is one of the largest databases of peer-reviewed articles and is widely known as a scientific source with a strong tradition in environmental sciences with a high impact factor. Next, the following search strings were established: "organic farming" and "bioeconomy". A total of 246 journal articles were retrieved. The titles and abstracts of these papers were then assessed for suitability to the horizon of the study, resulting in the selection of 36 articles for conducting the systematic review.

2.2. Selection of the Studies

To select a representative and relevant number of studies, we established inclusion and exclusion conditions based on fulfilling the following criteria: (1) the paper illustrates a theoretical interpretation of the concept of BE; (2) and/or the paper examines the implementation or assessment of one or more theories regarding the BE in organic farming; (3) and/or the paper discusses the implementation of biotechnology processes in organic farming. Articles that have only an outlook on OA and sustainability were excluded. Even not making clear reference to the concept of BE, if the results potentially made a contribution to the theory of BE, this was taken into consideration. Each paper was read independently and screened through inclusion and exclusion criteria. According to Crowther et al. [17], excluding duplicate studies eliminates the overrepresentation of that particular data in the systematic review. This process resulted in a total of 36 papers being selected.

2.3. Analysis and Synthesis

To facilitate extracting a quality assessment of standardized data, we followed the analysis categories, named: the publication author, journal, year, title, objective, theories used, location, unit of analysis, methodology, and main findings. This represents the primary data from which we proceeded to further create a synthesis of the relevant elements for the study [18]. Accordingly, the synthesis facilitated the subsequent handling of the data for the purpose of establishing relationships and constructing the evidence [19].

Regarding the distribution of papers, we discovered that most of the selected articles were written and conducted in Europe, as shown in Figure 1. Of the reviewed articles, 23 were from Europe, and 18 of these overall were from Western Europe. Other continents are represented by no more than 1 or 2 articles, except Asia, with 7 studies. The total number of papers presented in Figure 1, exceeds the total number of reviewed articles (36) because some empirical studies were conducted in more than one country.

The articles were allocated according to the location of the research, in case of an empirical paper or the region of the main author of the research, in case of review or discussion paper. Regarding the journals in which the texts were published, our study retrieved articles from a highly dispersed number: the 36 studies are distributed across 22 different journals, as illustrated in Figure 2.

The highest concentrations of articles are Renewable Agriculture and Food Systems (four texts) and Journal of Cleaner Production, Bioresource Technology, Agriculture, Ecosystems, and Environment and Agricultural Systems, each with three studies. In relation to the categories of the research, most articles selected conducted empirical research methods (26), while seven were literature reviews, two were discussion papers, and one was a mix of empirical and review research, according to the graphic distribution depicted in Figure 3.

The period of publication of the studies ranges from 2011 to 2019, and the interval with the highest number of academic productions was from 2016 to 2017 (18 of the 36 selected articles), as shown in Figure 4.

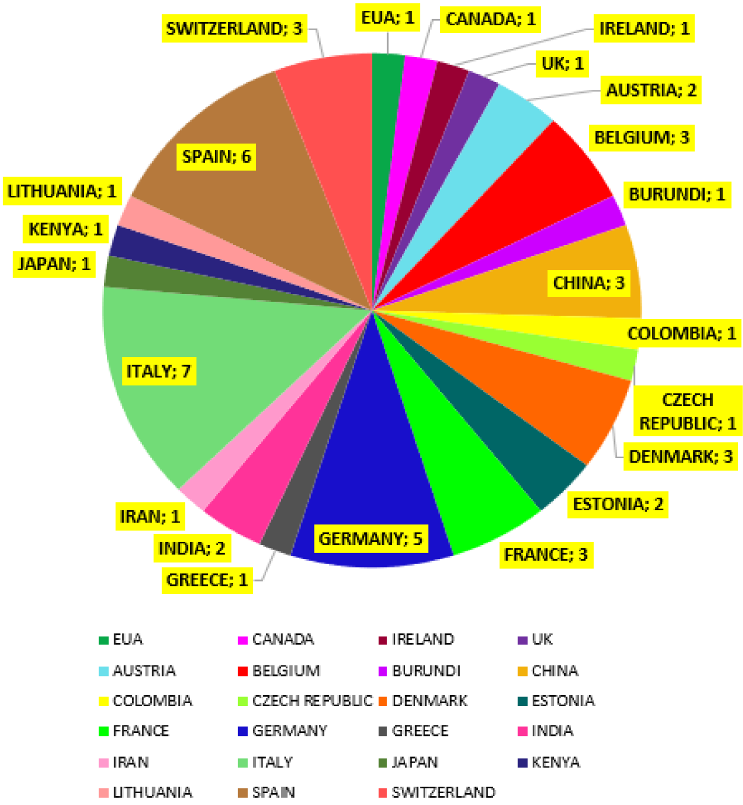

Figure 1. The distribution of the studies' origin per country.

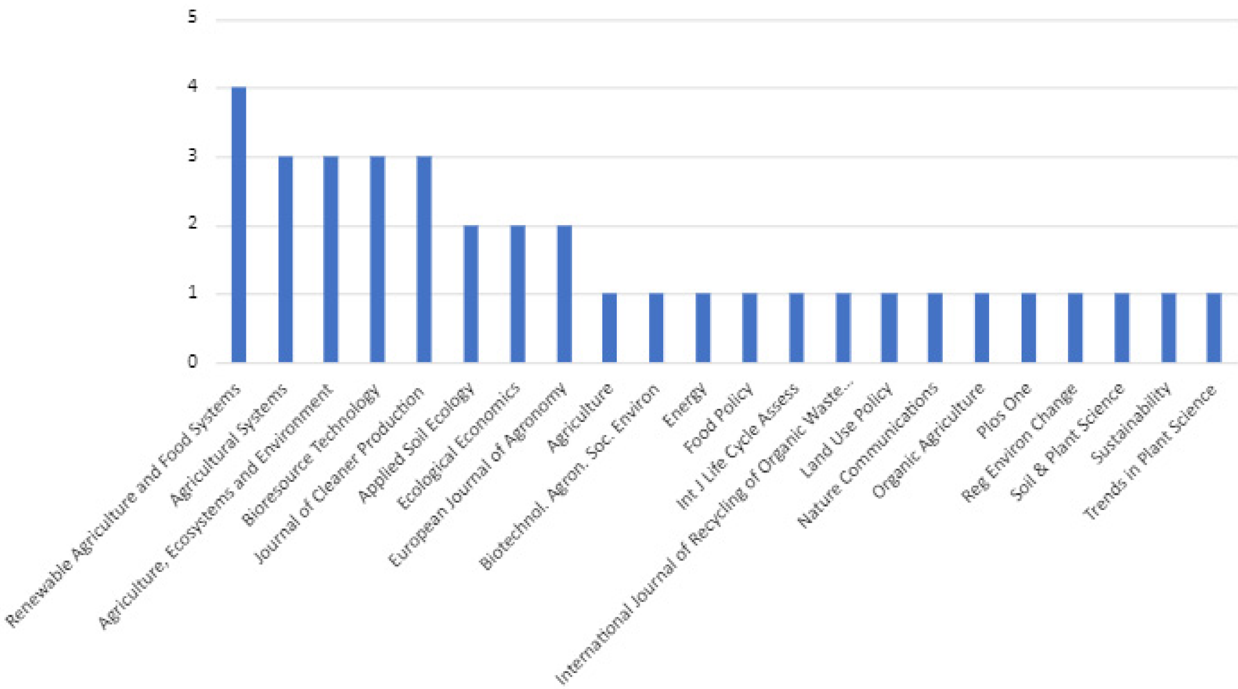

Figure 2. The journals with articles published.

2.4. Reporting and Use of the Research Results

After collecting suitable studies, we returned to the question that prompted this research and considered whether the evidence gathered was sufficiently strong to answer it conclusively. We opted for the construction of a conceptual framework, as it is an efficient way to categorize and describe the concepts relevant to the study and map the relationships among them. To build a suitable foundation, the utilization of previous work is required to demonstrate connections, illustrate trends, and provide an overview of the concept, literature, or theory [20]. In this concern, we proceed to Section 3 to assess the findings of the selected studies, categorize their results, and identify the core research themes and gaps to provide future research directions.

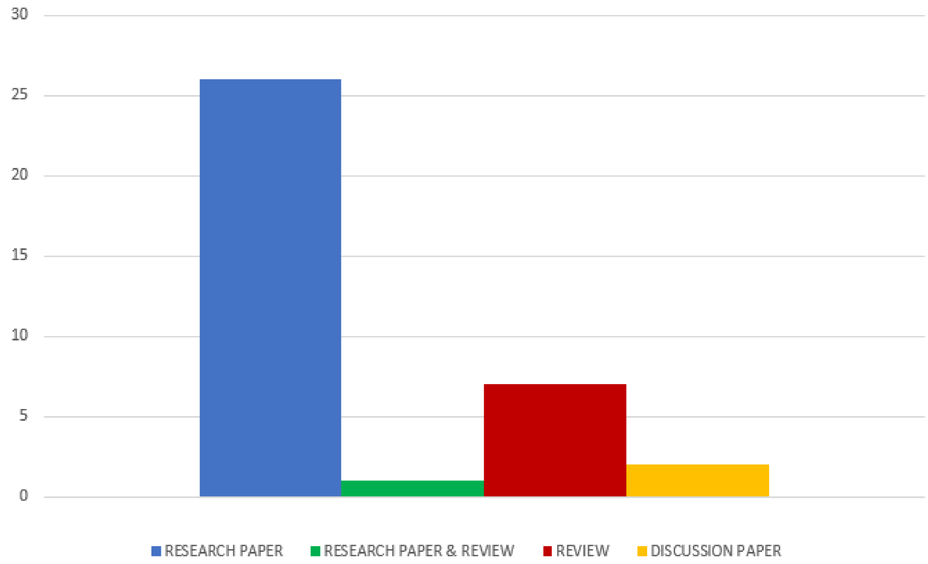

Figure 3. The categories of the articles.

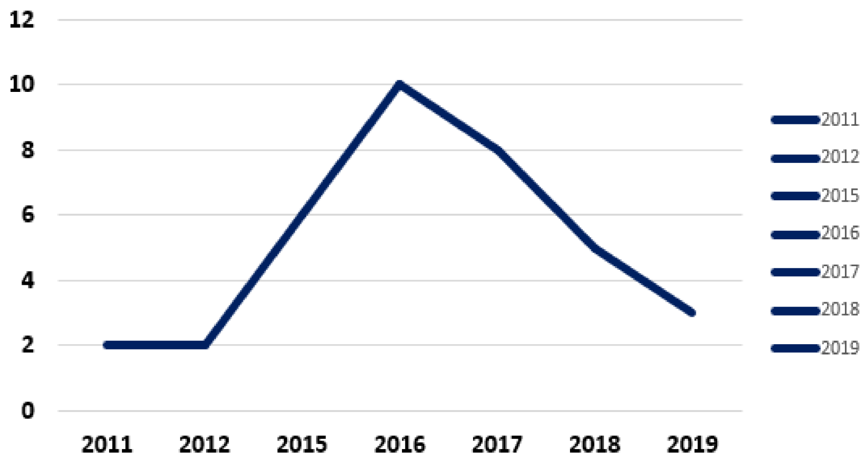

Figure 4. The publication year of the articles.

3. Results

The content analysis of selected papers makes it possible to identify the concept, key aspects for the development of BE and the relation between OA and BE. We present the descriptive results below and propose a conceptual framework presenting benefits of OA under perspective of the main aspects of BE, and references of the studies assessed. Each topic identified will be explained before the general findings are discussed.

3.1. What Is the Bioeconomy?

It is fully recognized that current production and consumption patterns are causing several environmental problems worldwide. Human activities are the main driver of the intense depletion and contamination of natural resources, which impedes global economic growth and the overall well-being of society. In particular, the use of fossil fuels has contributed to environmental pollution, greenhouse gas emissions, global warming, and climate change.

To mitigate and eradicate these problems, the BE was conceptualized. BE is the diversion of dependence on fossil fuels to a situation in which the use of biomass occurs, not only as a food supply but also as raw material for industry and energy production, including the supply of biodiesel. The main debate surrounding the BE concerns its sustainability [8,10,21]. Bioeconomic is a conceptually abundant border terminology for a green and low-carbon or carbon-free economy. The requirement to eliminate dependence on fossil fuels poses a challenge to developing the bio-based economy. In this economic system, agriculture will provide quality food to the growing world population and raw materials for industries and energy [21].

BE proposes innovative solutions to help society live within its limits, seeking to decouple economic growth from environmental degradation. It has political resonance to assist the nations in meeting the requirements of existing policies or newly defined objectives, such as those related to the Paris Agreement [9,22]. Radical innovation in this context will play a fundamental role since it will be necessary to achieve these objectives, not only in technological terms but also through the policies, practices, collaborations, and behaviors that guide this transition [9,23].

The foundations for the BE in Europe were already being laid in the 1993 EU White Paper entitled "Growth, competitiveness, employment: the challenges and the way forward for the 21st century", which emphasizes the need for non-physical investments based on knowledge and the role of biotechnology in innovation and economic growth. The Lisbon Agenda in 2000 also called for global leadership in the "knowledge-based economy" to guarantee competitiveness and economic growth. It was only in the middle of the following decade, however, that BE, as a much more ambitious and political agenda, entered the relevant EU political discourse [11].

In the early 2000s, governments around the world began to adopt so-called "biotechnology strategies". These strategies broadly encompassed a set of economic activities aimed at the production of manufactured goods and sustainable fuels. In roughly a decade, there has been a clear shift from the formulation of biotechnology strategies to the practical implementation of BE policies. Thus, a change has occurred in the definition of the set of economic and financial activities involved in the implementation of actual policies. In the period from 2000 to the present, realizing the BE has become a highly desired goal [11].

Finland was one of the first countries to develop its own bioeconomic strategy. The final version of the "Finnish BE strategy: sustainable growth from the BE" was published in 2014. In October 2018, the EU launched an updated bioeconomic strategy with the aim of stimulating the replacement of fossil carbon by raw material for biomass in industry and energy production, thereby preserving ecosystem services [24].

The BE can also affect citizen's rights and interests and their economic opportunities and well-being. A sustainable, environmentally, and socially responsible forest-based BE requires decision-makers, citizens, and the forestry sector to display the capacity and willingness to adopt a responsive approach [25].

Some critics of BE argue that there has been a weakening of the social dimension in making strategic decisions, especially regarding the understanding of environmental rights as a matter of basic justice. Moreover, such critics contend that the transition to the BE must guarantee improvements in the ability to achieve results that citizens value, such as the well-being (social, economic, and environmental conditions or training states) of present and future generations [25]. It has also been argued that there is a lack of a dynamic balance between the environmental, social, and economic dimensions—respecting the guidelines of the Brundtland report—within the framework of the EU's BE policy since the economic dimensions and concerns prevail over the environmental and social dimensions.

In view of the possible negative consequences of biomass production, there is an urgent need to define and expand the scope of the BE, as well as to include environmental and social concerns and safeguards [11]. There are also several gaps in the analysis of how to implement bioeconomic strategies and regulations, especially in a global context [8], in addition to the lack of a deeper understanding of sustainability and sustainable resource management [11].

3.2. Identification of Key Aspects for the Development of Bioeconomy

The following paragraphs provide a detailed description of the aspects that contributes to the development of the BE.

A mature and sustainable BE must offer global food security, improve nutrition and health, create innovative bio-based products and biofuels, help agriculture, forestry, aquaculture, and other ecosystems to adapt to climate change [25]. BE is an opportunity to boost innovation, create jobs in rural and industrial areas, reduce fossil fuel dependence, and improve economic and environmental sustainability [26].

The data presented in Table 1 shown the relevant aspects for the development of BE, which are the following: implementing life cycle perspectives for the certification and improvement of the sustainability of BE products throughout the supply chain [27]; promoting the involvement of citizens and final buyers to reduce the gap between science and society, with more research networks, education, training, and clusters of agricultural cooperatives [9,11,28]; using water, energy, and land resources sustainably [10,21,29]; improving productivity and land use through better crop management [10,21]; generating opportunities to separate agricultural growth from environmental degradation through more sustainable production methods using biotechnology [10]; utilizing biomass more efficiently [10,21]; achieving social well-being [22]; employing clean technologies to decrease greenhouse gas emissions, minimizing the inputs, and maximizing the outputs of the system [7]. To facilitate achieving these objectives, indicators and targets may be derived and developed to provide direction for the sustainable development of the BE [27].

Table 1. BE key aspects.

BE Key Aspects	**References**
Biotechnology	Rosegrant et al. [10]
Improved crop management	Rosegrant et al. [10]; Uzoh and Babalola [21]
Efficient utilization of biomass	Rosegrant et al. [10]; Uzoh and Babalola [21]
Well-being	Mustalahti [22]
Research networks, education, training and clusters	Devaney and Henchion [9] Ramcilovic-Suominen and Pulzl [11]; Scheiterle et al. [28];
Use of water, energy and land resources sustainably	Rosegrant et al. [10]; Uzoh and Babalola [21]; Hertel et al. [29]
Clean technologies	Sarkar et al. [7]
Efficient utilization of biomass	Rosegrant et al. [10]; Uzoh and Babalola [21]
Life cycle assessment	O'Brien et al. [27]

In the next section, we discuss how OA can be associated with BE in these bottom-up aspects.

3.3. How Can Organic Agriculture Be Part of the Bioeconomy?

Although most of the articles we identified in our review do not directly quote the word "bioeconomy" concerning OA, we characterized 36 articles from various journals whose results contained elements consistent with the dominant characteristics of the BE.

The activities conducted through organic cultivation contribute strongly to the increase of social welfare, the rational use of natural resources, such as water, land, and energy, the improvement of land cultivation and the mitigation of the emission of greenhouse gases. These activities also have a wide range of consumer acceptance because they are linked to health promotion and sustainable ecological development. Innovative and transformative solutions derived from OA contribute to sustainability. They can play a role in the BE, which adds value to products and drives all the factors listed above, thereby contributing to low-carbon agriculture. Other factors, including the life cycle of the organic chain, education, training, and the formation of groups such as cooperatives, are part of this web that aligns the objectives of sustainable development with economic practice. Each of these aspects are discussed since they will form a framework for OA from the perspective of these BE key aspects.

3.3.1. Biotechnologies

Several authors deal with biotechnologies that have been or could be successfully applied in organic practice, such as improving the vegetation cover of the soil, that is, the incorporation of organic matter that affects the composition of soil bacterial communities, nutrient cycling, and other crucial functions for health and crop growth [30]. Furthermore, the application of new techniques, such as reproduction, disease management, and breeding strategy, will help to improve the general training of farmers and promote OA [31,32].

The diversity of strategies shows that organic farmers use innovative approaches to implement conservation agriculture without herbicides. Such strategies are mainly based on two distinctive technical options: (1) intensive non-inversion tillage or (2) biological regulation with green manures. Peigné et al. [33] claimed that the identification of innovative crop management strategies is the first step to design new organic cropping systems that integrate conservation agriculture principles in a more systematic way.

Developing effective biotechnology for recycling a wide range of organic waste for agricultural production is important for converting organic waste into useful organic fertilizers. The techniques that involve earthworms, which consume a variety of organic materials, are suitable for this purpose. This technique, known as vermicomposting, is simple and facilitates the recycling of different organic wastes since earthworms excrete about 90% to 95% of the ingested materials [12]. The high nutrient content and other beneficial properties of vermicompost can help to increase the production of healthier crops. Hence, the vermicomposting technique is a simple, easily adopted, and effective biotechnology for recycling a wide range of organic waste for agricultural production [12].

The rhizobacteria exploitation technique is knower as a means to improve health and growth, which promotes plant growth, promises a sustainable agriculture success story [34]. The rhizosphere is closest to the soil in the plant's root system, and the microbes that inhabit this area are able to colonize plant roots very efficiently. These microbes are known to improve the health and growth of plants. Moreover, some of these microbes could possibly function as replacements for current techniques for suppressing pathogens. Several mechanisms are involved in the suppression of plant pathogens, which are often indirectly linked to plant growth. The microorganisms present in the rhizosphere play an important role in the ecological suitability of their plant hosts. Thus, the exploitation of plant growth-promoting rhizobacteria could guarantee further success in practicing sustainable agriculture [34].

New technologies need to be assessed and existing methods reviewed to enhance the efficiency and productivity of OA. However, such activities should not be performed at the risk of jeopardizing health and well-being. A controversial technique not yet accepted by practitioners of agroecology in many countries is that of rewilding. This practice was studied by Andersen et al. [35] and involves generating a cultivation plant that carries a principle of a wild-type allelic variant through reproduction by introgression or precision. In some countries, OA is open to such new technologies, which aim to maintain species diversity and adaptability, especially in situations of soil adaptation and rebalancing, by not using synthetic inputs. These biotechnology techniques consequently contribute to the improvement of soil cover and the nutrient cycle. The construction of organic matter in the soil is the principle of ecological manipulation that favors the incorporation of a greater diversity of rotated crops, thereby avoiding the use of synthetic inputs, which pose significant threats to the health of humans and ecosystems.

3.3.2. Improved Crop Management

When dealing with sustainable intensification, soil fertility is a major factor to be considered. Since the Green Revolution period, the management of soil fertility has centered on the use of inorganic fertilizers, but this practice has not proved sustainable. The use of both living and dead organic matter has been suggested as the means to sustain soil fertility, so the exploration, management, and manipulation of these rhizosphere organisms are vital to maximizing crop yields [24]. The biotechnology techniques described in the subsection above are essential in promoting nutritional health and increasing soil productivity. Accordingly, developing technological innovations that aid in suppressing the use of external inputs, such as herbicides and pesticides, is particularly important.

Improving farm management and technologies can increase the efficiency of resource use and maintain high-yield performance [36]. Organic management strategies, such as cultivating cover crops with reduced tillage, can provide a robust management tool for improving weed management practices, minimizing the risk of soil erosion, creating organic matter, and incorporating a greater diversity of cultures into crop rotation [37]. Organic agroforestry, which combines planting trees with agricultural activities, also has the potential to increase the dry matter yield of the entire system and to improve the efficiency of nitrogen utilization [36]. Additionally, agroecological service crops can improve environmental performance by increasing the potential energy that can be recycled within the cropping system [38].

With regard to improving soil quality, crop diversification practices, such as including legume rotations with cereal rotations in the preparation of cultivation, furnish examples of effective techniques [39,40]. Such methods provide the nutrients necessary to dispense with synthetic fertilizers. Furthermore, this practice of including legumes and organic inputs contributes to diversity, as it affects the size and activity of the soil microbial community [41,42] and the growth of organic matter [42].

Using green manure is another way to increase the efficiency of cultivation in organic management. Implementing this method provides efficient nutrients, especially nitrogen, through animal excrements, thereby contributing substantially to increased crop productivity. The use of green manure throughout the year and legume-based crops both contribute to increasing production [43,44].

3.3.3. Well-Being

Concerning the principles of well-being, the improvement in the quality of life of consumers and organic producers is expressed through reports of a “sacred” relationship between the land and food. Organic farmers are strongly attached to their method of production by conviction and values [45]. Moreover, farmers who apply organic practices reject actions such as the use of herbicides and are concerned with achieving production quality [46]. OA allows small farmers to improve their livelihood, especially when they have access to training and can organize themselves into groups [47,48].

The consumer well-being generated by OA consists of promoting food security for the population [49] by giving up the use of herbicides, insecticides, or synthetic fertilizers. OA can bring important benefits to human health and the environment, in addition to promoting the more compassionate treatment of animals [50]. The formation of prosperous and resilient agricultural models will enable farmers to be more competitive and increase their confidence [51] in facing the challenges entailed by a future of climatic uncertainty and the need of increasing production, which will further intensify competition in food production.

3.3.4. Education, Training, and Clusters

Involving farmers and integrating participatory and modeling methods in different possible future scenarios has the potential to produce innovations, as well as reveal the trade-offs and clarify the costs and benefits associated with the practice, thereby promoting more informed decision making by farmers [52].

The formation of a knowledge network, or even the formation of cooperatives, has great potential in OA, not only for increased profits but also for facilitating the engagement of producers, innovation, local social changes, and better decisions [51–53]. Cooperatives and technical training contribute to the promotion of sustainability factors and to the application of new technologies capable of mitigating environmental impacts and promoting local health.

Among organic producers, there is a common idea of contributing to the cohesion of a network and its progressive structuring. This interaction is considered the necessary platform for producing innovation and local change [53].

According to Qiao et al. [54], to improve the livelihoods of small-scale farmers, the local government should further support the formation of cooperatives among organic farmers to ensure that all farmers are part of such cooperatives, as this initiative will ease market access, improve capacity building in terms of good farming practices, and increase bargaining power. Additional mechanisms should be established to provide farmers with more land to enable increased farm sizes.

3.3.5. Use of Water, Energy, and Land Resources

OA that emphasizes local and indigenous knowledge can improve social capacity, reduce poverty, and gradually increase the quantity of natural resources [55]. In addition, organic cultivation is more water-efficient per area of cultivation [56] and protects water courses because it facilitates an improvement in the soil nitrogen cycle. Such protection extends to not using pesticides, insecticides, and pesticides, which contaminate the air, soil, and consequently, rivers. By not using external synthetic inputs, OA also prevents these compounds from spreading into the environment and entering the food chain, which threatens human health and the health and biodiversity of ecosystems [50].

OA faces the challenge of remaining competitive and increasing production yields compared to conventional agriculture, but without harming ecosystems. In contrast, it seeks to facilitate increases in biodiversity and environmental quality. The critical challenges of land demand, and to a certain extent N-supply, involved in large-scale conversion to organic production, reflect current perspectives on maintaining soil fertility, nutrient recycling, and ecosystem services [57].

The degree of energy efficiency will be determined by management practices and geographical location. Since OA utilizes a small number of external inputs or none at all, it is claimed to be more energy-efficient compared to conventional farming. Implementing best management farming practices mainly entails using renewable energy inputs, which leads to lower greenhouse gas emissions. In a study conducted by Taxidis et al. [58], the energy efficiency of organic cultivars was compared with conventional types. The authors concluded that both non-renewable energy inputs and non-renewable energy consumption were significantly lower in organic than in conventional olive groves.

Finally, because OA is based on ecological principles, it positively affects the environment by strengthening adaptation strategies, reducing greenhouse gas emissions, and increasing the quality and quantity of natural resources [55]. It is also more conducive to promoting soil health and biodiversity while reducing contamination from agrochemicals [50], especially compared with conventional methods. OA also increases biodiversity because it forbids synthetic pesticides and fertilizers.

3.3.6. Life Cycle Analyses

In comparative studies of organic and conventional agriculture, the life cycle analysis technique is widely used, and for BE, it is recognized as a significant statistical analysis tool for certification [27]. In a study conducted by Hokazono and Hayashi [59], the organic rotations of rice, barley, and soybeans were evaluated as producing higher yields than the same rotations in conventional cultivation after using the product life cycle analysis method to assess sustainability factors. This result is similar to that reported by Tricase et al. [60], whose study utilized barley cultivation as a measure.

Despite the result demonstrating that conventional agriculture is more efficient in production, organic cultivation proved to be the most environmentally sustainable solution. In a survey conducted in Greece by Foteinis and Chatzisymeon [56] with lettuce cultivars, since the same results were obtained after comparison per unit of product (ton), conventional agriculture achieved better performance in the life cycle assessment. However, when the unit of analysis was per unit area (1 ha), OA was ecologically superior due to differences in productivity between the two cultivars.

Therefore, the product-oriented expression, which is equivalent to driving the life cycle assessment product, revealed that organic conversion tended to be efficient, regardless of the use of physical productivity (the functional unit of the product's mass measured as average annual energy yield) or monetary productivity [59].

3.3.7. Greenhouse Gas Emissions

The possibilities with the most significant potential for reducing environmental pressure are the switch from machinery powered by fossil fuels (tractors and harvesters) to machinery powered by biogas (used to harvest crops in some cases) and the transition from conventional cultivation (with pesticides) to ecological cultivation (without pesticides) [61]. A shift from conventional agricultural practices to OA and using renewable energy sources has considerable potential for achieving more sustainable agriculture and strengthening a regionally based economy [61].

Regenerative OA can mitigate greenhouse gas emissions, minimizing soil erosion and runoff by using conservation crops [62]. Agricultural emissions from crop and livestock production grew from 4.7 billion tons of carbon dioxide equivalents (CO_2 eq) in 2001 to over 5.3 billion tons in 2011, a 14% increase. This increase occurred mainly in developing countries due to an expansion of total agricultural outputs [63]. However, increasing the area cultivated with OA by 1% can decrease greenhouse gas emissions by 0.049% [64].

Foteinis and Chatzisymeon [56] compared the CO2 environmental footprint in organic and conventional lettuce cultivation, demonstrating that the environmental footprint and CO2 emissions were 11% and 15% lower, respectively, in organic compared to conventional lettuce cultivation, when sustainability is evaluated in terms of the area (ha) of cultivation. Conversely, traditional lettuce cultivation showed better environmental performance than organic methods in terms of CO2 emissions and total environmental impacts, with 51% and 53%, respectively, when the amount of lettuce produced is used as a functional calculation unit. This outcome is attributed to the fact that the organic system requires a significantly larger cultivation area to achieve the same production yield as the conventional crop.

The sustainability of organic cultivation is strongly related to the transport of organic fertilizer (manure) to the field and its dissemination and mechanical application [56]. The comparison of organic and conventional farming systems depends heavily on the functional unit that is used and the local receiving water bodies (e.g., sea, river, lake). It has been shown that management strategies that introduced agroecological services crops into the crop rotation were more likely to enhance environmental performance by increasing the recycling energy outflow than those more market-oriented strategies that did not utilize such crops [39].

The production of biomass-derived from the introduction of leguminous rotations on cultivars facilitates the energy efficiency of the farm through the production of biogas. Furthermore, bioenergy production from by-products and residues eases the burden on land-use competition because no additional farmland is needed to raise food output and produce biomass energy [65]. Siegmeier et al. [65] noted that through biogas integration, organic farms could contribute to renewable energy supply without additional need for land while simultaneously increasing food output. The authors also concluded that utilizing biogas reduced labor and energy costs while increasing farm productivity, stability, and resilience. Since energy efficiency is strictly related to the efficient utilization of biomass, we discuss this topic more deeply in the next subsection.

3.3.8. Efficient Biomass Utilization

Given that biomass has a high potential for reducing greenhouse gases [10,21], using biomass will result in a greater reduction of these gases. Biomass is an alternative resource that has great potential in the application and in mitigating climate change. The more enhanced the organic matter built into the soil, the better the quality of the biomass. In addition, the quality of biomass also depends on the efficiency of photosynthesis and the agricultural process, which results in competition within the food chain [66].

In this sense, anaerobic digestion is an efficient technology in terms of generating significant resource savings. As it converts different types of biomass, such as energy crops and domestic organic waste, into highly energetic biogas, this biotechnology could increase environmental sustainability [66]. However, it is required to control the emissions in the biogas production chain. Anaerobic digestion can produce biogas from many different sources of biomass while co-producing a rich digester [66]. Furthermore, it is necessary to consider that dry matter can induce pollution risks.

The digestate is a rich source of nutrients and is highly beneficial and inexpensive, as it uses a free farm resource, namely manure. A study conducted by Zhang et al. [67] that investigated the utilization of biomass residues made possible the development of a technique for producing biochar. This is a multifunctional material for agricultural and environmental applications, recognized as a high-efficiency and low-cost sorbent for different types of pollutant removal. This interaction is also noted in a study by Chen et al. [68], where the magnetic biochar exhibited a hybrid sorption property to remove organic pollutants and phosphate effectively.

A study by Plaza et al. [69] found that the application of biochar and organic fertilizer contributed to a significant increase in the organic matter content of the soil. The significant interaction effect observed between biochar and organic fertilizer factors on the organic carbon content associated with minerals was also highlighted. This finding suggested a biochar-promoting action in stabilizing carbon in organically fertilized soils by forming organo-mineral complexes. The potential utilization of biochar as a strategy to sequester carbon in soils could help to combat global warming [69]. Thus, biochar can contribute to the reduction of greenhouse gases [67,69]. The addition of biochar, for example, derived from wheat straw to the composting substrate can aid in sustainably managing agricultural waste [67].

The insights discussed above are presented in Table 2 and form a conceptual framework of each benefit from OA reviewed on this study and in accordance with the key aspects of BE.

Table 2. Conceptual framework with benefits from organic agriculture and in according to the bioeconomy.

Bioeconomy Key Aspect	Organic Agriculture Benefit	References
Well-being	Farmers who apply organic practices described a sacred relationship with the land and rejected actions such as the use of herbicides; the identity of coffee growers associated with place-based ties is boosted by the achievement of high quality of organic coffee production; Organic farmers are strongly attached to their method of production by conviction and values; many farmers appreciate environmental integrity; OA with an emphasis on local and indigenous knowledge enables smallholder farmers to improve their livelihood; OA ensures food safety for the population.	Hermann et al. [45]; Bravo-Monroy et al. [46]; Altenbuchner et al. [47]; Kamau et al. [48]; Gomiero [49]; De los Rios et al. [50]; Jouzi et al. [55]
Use of water, energy, and land resources	OA can provide sufficient food and simultaneously reduce environmental impacts if it is implemented in a well-designed food system with reduced animal numbers and animal product consumption and when food wastage is addressed; organic soil management practices contribute to increasing water and land quality; OA is more energy-efficient, utilizing fewer energy inputs in the system, along with renewable energy, and therefore lowering greenhouse gas emissions.	Chocano et al. [42]; Gomiero [49]; Jouzi et al. [55]; Foteinis and Chatzisymeon [56]; Muller et al. [57]; Taxidis et al. [58]
Biotechnologies	OA employs innovative approaches to implement conservation agriculture without herbicides; Organic farmings apply new techniques, such as disease management and rewilding, vermicomposting, and soil microbial technology applied in the rhizosphere.	Chattopadhyay [12]; Horrillo et al. [31]; Caproni et al. [32]; Peigné et al. [33]; Nihorimbere et al. [34] Andersen et al. [35]
Improved crop management	Agroecological service crops are more likely to enhance environmental performance by increasing recycling energy outflow; cover crop-based reduced tillage; diversification of crop rotations by the inclusion of legumes in a cereal rotation; green manure and legume-based catch crops contributed to enhancing yield.	Silva and Delate [37]; Navarro-Miró et al. [38]; Canali et al. [39]; Feiziene et al. [40]; Lori et al. [41]; Chocano et al. [42]; Shah et al. [43]; Maltais-Landry et al. [44]
Life cycle analyses	Life cycle analyses are often used to estimate efficient conversion to OA.	Foteinis and Chatzisymeon [56]; Hokazono and Hayashi [59]; Tricase et al. [60]
Education, training, and clusters	The common idea of OA is proven to contribute to the cohesion of a network and its progressive structuring, and this interaction is the necessary platform to produce innovation and local change; engaging farmers and integrating participatory and modeling methods have the potential to uncover tradeoffs and illuminate their associated costs and benefits to facilitate better-informed decision making; cooperative collective management combined with a constant flow of knowledge and learning contributes to creating more sustainable and resilient agricultural models.	De los Rios et al. [51]; Favilli et al. [53]; Qiao et al. [54]; Sylvestre et al. [55]
Greenhouse gas emissions	Lower total energy consumption in agroecological service with crops under no-till roller crimper; biogas integration in OA may contribute to increasing renewable energy supply and reducing greenhouse gas emissions; conservation tillage; biogas driven machinery.	Navarro-Miró et al. [38]; Foteinis and Chatzisymeon [56]; Maier et al. [61]; Frankova and Cattaneo [62]; Siegmeier et al. [65]
Efficient biomass utilization	Using of biochar; generation of bioenergy across anaerobic digestion; development of biodigesters.	De Meester et al. [66]; Zhang et al. [67] Chen et al. [68]; Plaza et al. [69]

4. Discussion

This section identifies contributions and novelty added for this article and encompasses the findings. This article aims to investigate the relation between OA and BE through a systematic literature review. The systematic review was structured according to the following guiding categories: (1) publication author, (2) journal, (3) year, (4) title, (5) objective, (6) theories approached, (7) location, (8) unit of analysis, (9) methodology, and (10) main findings.

The first scientific contribution of this paper is a comprehensive review and analysis of articles concerning contributions of OA related to the BE key aspects. We found evidence that OA contributes to the promotion of sustainability, in the same way that the promotion of sustainability is the main objective claimed by the BE concept. The second contribution is a conceptual framework needed to integrate these perspectives into a model which embraces evidence and reinforcing the common aspects between OA and BE.

Our systematic review identified that most of the 36 papers assessed are individual experiences, presenting specific evidence of organic products with a given management organic practice. While some reviewed studies demonstrated that principles transformed in practices would be essential to activate sustainable agriculture productivity to meet food security goals [32,41,47,50,51,55,57], they fail in not presenting methods to implement OA without dependence on externalities. It is clear enough that new technologies need to be assessed and existing methods reviewed to enhance performance in conservation and sustainability. These new technologies should encompass most of the inequalities between regions, contemplating demographic, climatic, and economic specific characteristics.

Scientific publications on OA related to the development of BE are limited, as most of the papers are not specifically linked to the BE, besides the approach of subjects could be associated with the concept. The issue is minimally explored and needs further clarification through scientific research, as little has been written about management strategies of OA, suitable to be replicable in farms of any continent to achieve principles of BE. This lack of practical guidelines is an opportunity for researchers to identify best practices in common with farmers around the globe in order to achieve and promote the BE principles, evidencing the need to enhance sustainability in farming food systems.

We also identified a high dispersion of research concerning scientific journals, although when the analysis is about geographical areas, the identified scenario is different. The studies reported herein suggest a concentration of research in Europe and this could be explained as BE is a concept originated in this continent and still not largely disseminated to other regions. Of the reviewed studies, 23 were conducted or originated in Europe.

Although several authors published papers about how OA could collaborate on avoiding the threat of global climate change (e.g., reducing environmental impacts and greenhouse gas emissions) [37–40,42–44], these results were a consequence of local empirical strategies of positive evidence presented. Furthermore, these studies just focused on some key areas and not encompassed a global strategy viable to different countries, climates, characteristics of farming, and public support.

An example of a practice variable between regions is presented in the review conducted by Andersen et al. [35], which is the technology genetic engineering. Depending on the region, this kind of engineering is not acceptable by local organic regulations. The debate concerning what in terms of strategies derived from the BE will be useful for OA is essential, considering that in some countries, legislation about OA considers genetic engineering incompatible with the principles of sustainability of the environment. Concerning this, an alliance between OA and BE is necessary, which means regulatory policy treating what kind of organic farming strategies can be useful on achieving sustainability, promoting BE without compromising ecologic performance.

Clearly, agricultural farmers demand technological support to advance in terms of innovation and sustainability, as preconized in the main concepts about BE [9,10,22,23]. The association of farmers in cooperatives is crucial to facilitate paths to achieve public support. Many authors conclude that a supportive policy environment for the development of solutions will be important [8–11] not only to perform transformative strategies for OA, but also for effective adoption of the BE.

Several authors agree that OA is capable of mitigating environmental impacts [42,50,57], promoting wellbeing for the intricate [45–47,51], and increasing profits [47,51,55]. An example where a situation viable for BE occurs is when the biomass is generated. Biomass can be combustible for the development of the BE, as it is related to raw materials that contribute to a green economy and clean energy. The biomass will be the raw material of the production of biogas in organic farming, a combustible capable of contributing to renewable energy supply, although authors miss conclusions on how to fit production of enough biomass capable of generating biogas in small properties, without even more dependence on external factors [65,66].

To make strategic decisions favorable to social justice, some critics of BE argue that there has been a weakening of the social dimension, especially in connecting citizens on the debate about their well-being and capabilities on the action for environment conservation [22,25]. Moreover, such critics contend that the transition to the BE must guarantee improvements in the ability to achieve results that citizens value. Many authors conclude that OA theoretically allows small farmers to improve their livelihood, especially when they have access to training and the capacity to organize themselves in cooperatives [46,51,53,54]. The local government should further support the formation of cooperatives among organic farmers. Authors concluded on the necessity of cohesion of a network and its progressive structuring. This interaction is the necessary platform to produce innovation and local change, engaging farmers and integrating participatory [9,11,28,51,53].

A strong focus on profitability was observed in several articles, especially in comparison between organic and conventional farming. Besides focusing on production and profitability, sustainable food systems need to address waste [55]. For this reason, efficient biotechnology measures could be taken not only to follow local legislation but also as an opportunity at the commercial level to use municipal and/or other sources of wastes, and the final product could be marketed as good quality organic manure.

Often the authors of the papers accessed on this systematic review share their experiences, including additional research needed. Altogether, the diversity of approaches mapped in this review, as well as the practical focus of discussions, offers a set of experiences as well as some conceptual guidance for agricultures and researchers interested in promoting sustainability in organic farming, aligned with the BE concept.

The results of this study can be used to define new research, as it could be considered as the first step for practical guidance between BE and OA. The new studies, to advance in OA and BE, should approach a holistic vision with the help of the set of key demanding issues as stated in the framework specifically designed to align organic practices into BE principles. It is possible to state that there is a lack of a consistent set of indicators for assessing OA practices aligned with the BE context. A set of indicators can be formulated in order to assist the planning of management for organic farmers articulated to achieve the development of a BE.

5. Conclusions

The diversity of the articles reviewed in this paper is a piece of work representing a first step in the direction of a necessity to the formulation of an intersection between BE and OA. This systematic review of the literature enabled us to formulate a framework with a multidimensional vision between BE and OA. This framework is a conceptual guidance, the first step to achieve strategic management for farmers or researchers that wants to map the key issues deriving from the extant research. In particular, the framework highlight results that point out the benefits of OA under perspective of the BE main aspects.

As discussed above, most of the reviewed articles focus on specific contributions of OA and not encompassing a multidimensional cascade of benefits, even less approaching the BE concept. Studies conducted in organic farming fall to connect a multidimensional approach considering the key aspects for the development of BE concept and OA potential.

To consolidate policy of best practices for innovation in OA in order to promote a BE, the conceptual proposed framework could be beneficial, especially for small farmers who need to manage important strategic issues, maintain or acquire certification. At the same time, the development of the BE in organic farming can be useful for the following aspects: increasing productivity, maintaining crop nutrition and improving ecosystem services provided by properties, fostering resilience to climate variations, and offering social benefits, including increased consumer welfare and better conditions for farmers and animals inhabiting agricultural areas.

Empirically, OA can be substantially balanced in order to contribute to a more sustainable future through addressing growing climate challenges. This study may be considered a first step towards integrating the two approaches examined. However, one of the paper's verified limitations is the lack of validation of these techniques in a case study. Obtaining such validation can therefore be proposed as a future research route, enabling a better understanding of all the features and approaches considered from a theoretical viewpoint. The validation of the framework will be necessary to further understand relevant critical points and real-world benefits.

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