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AGROECOLOGY-BASED AGRICULTURE TO SUPPORT SUSTAINABLE AGRICULTURE: A SYSTEMATIC LITERATURE REVIEW

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Abstract

Agroecology-based agriculture is an approach that integrates ecological principles into agricultural systems to achieve environmental, social, and economic sustainability. This study conducted a systematic literature review of recent publications to evaluate the contribution of agroecology in supporting sustainable agriculture and to identify supporting factors and challenges in its implementation. The results of the study show that crop diversification, utilisation of local resources, maintenance of soil fertility, and natural pest control are agroecological principles that contribute significantly to ecosystem stability and agricultural productivity. On the other hand, the successful implementation of agroecology is greatly influenced by policy support, the role of farming communities, access to training, and the availability of markets for agroecological products. However, challenges such as the dominance of conventional agriculture, limited access to resources, and cultural resistance remain major obstacles. This study recommends the application of multi-stakeholder collaborative strategies to strengthen the development of agroecology as an effort to transition to a sustainable and resilient agricultural system.

Keywords: Agroecology, sustainable agriculture, systematic literature review, crop diversification, biological control, policy support, implementation challenges.

Introduction

Modern agriculture, with all its technological advances and production intensification, has succeeded in significantly increasing food production in recent decades. Through the use of chemical fertilisers, synthetic pesticides, high-yielding varieties, and modern irrigation technology, farmers have been able to achieve high levels of productivity to meet the growing food needs of the global population (Martinez-Abraham, 2023) . However, this success has not been without serious consequences such as soil degradation, environmental pollution, loss of biodiversity, and increasingly alarming climate change. The accumulation of these negative impacts raises serious questions about the extent to which modern agricultural systems can contribute to long-term sustainability (Bharucha & Prabhu, 2025) .

The degradation of natural resources caused by intensive agriculture has prompted scientists, policymakers, and farming communities to seek new, more environmentally friendly and sustainable approaches. The challenges of agricultural development today are not only about increasing food production, but also maintaining ecological, social, and economic sustainability (Hammada, 2024) . Therefore, an

agricultural paradigm is needed that can strike a balance between productivity and sustainability. This is where agroecology comes in as one potential answer to the crisis in contemporary agricultural systems.

Agroecology is not merely a method of crop cultivation, but a scientific and practical approach that integrates ecological principles into agricultural systems. This concept emphasises the importance of crop diversification, natural soil management, the use of local resources, and the application of proven traditional knowledge. With this approach, agroecology seeks to create a more resilient, efficient, and sustainable food system. In addition, agroecology also emphasises the active involvement of farmers in decision-making and the important role of local communities in maintaining the balance of ecosystems (Hidayat et al., 2023) . Apart from ecological aspects, agroecology also has a very important social dimension. Agroecology-based agriculture not only aims to achieve environmental balance, but also seeks to strengthen farmers' independence, improve their welfare, and create a fair food system. By focusing on the principle of social sustainability, agroecology seeks to reduce farmers' dependence on large corporations in terms of seeds, fertilisers, and markets. This principle is in line with the idea of food sovereignty, which gives local communities the right to determine their own food systems (Susanti et al., 2024) .

Economically, the application of agroecology can provide long-term benefits through increased production cost efficiency, as it reduces dependence on external inputs. The use of organic fertilisers, ecology-based pest control, and the utilisation of crop diversity can reduce expenses (Nikezic, 2022) . Although agroecology yields may initially be lower than those of intensive agriculture, in the long term this system has proven to be more stable and resilient to shocks, including climate fluctuations and agricultural input price volatility. Thus, agroecology is not only an idealistic concept, but also a sustainable economic strategy that can support farmers' welfare (Kocira, 2020) .

In the global context, the emergence of food crises, climate change, and excessive dependence on synthetic inputs reinforces the relevance of agroecology. International organisations such as the FAO recognise that agroecology is one of the key strategies for addressing future global food challenges (Faisol & Atekan, 2020) . Several countries have adopted policies that support agroecological practices as part of their national food security systems. This indicates a global trend towards transforming agricultural systems to be more environmentally friendly and sustainability-oriented (Fitri & Usni, 2024) .

In Indonesia, the application of agroecology is also gaining attention, especially in addressing food security issues and environmental damage caused by conventional agricultural practices. With its rich biodiversity and local wisdom, Indonesia has great potential to develop agroecology-based agriculture. Various traditional farming communities in the archipelago have actually long practised agricultural patterns that are in line with agroecological principles, such as intercropping, agroforestry, and

organic soil management (Kalawawo, 2023) . However, the challenges of modernisation and industrialisation often displace these practices.

Despite its enormous potential, the implementation of agroecology is not without challenges. One of the main obstacles is the continued dominance of the conventional agricultural paradigm, both in government policy and at the farmer level. Additionally, market access for agroecological products is often limited, meaning that farmers do not receive adequate economic incentives. Other factors such as a lack of applied research, low consumer awareness, and limited technological support also hinder the development of agroecology. Therefore, a systematic literature review is needed to map out the opportunities and obstacles in the application of agroecology more comprehensively.

Research Method

The research method used in this study was a systematic literature review that was structured and transparent in order to obtain a comprehensive overview of agroecology in supporting sustainable agriculture. The research process included the identification of literature using international databases such as Scopus, Web of Science, and Google Scholar with the keywords "agroecology", "sustainable agriculture", "ecological farming", and "systematic review" (Ferrari, 2020) . The articles considered were limited to publications from the last 10 years, written in English or Indonesian, and relevant to the topic. The next stage was literature selection using inclusion and exclusion criteria to eliminate articles that were not relevant to the context. Articles that passed the selection were then subjected to data extraction to gather information on agroecological principles, contributions to sustainable agriculture, and supporting factors and challenges in their implementation. All data obtained were analysed narratively using a thematic approach, resulting in a synthesis that could answer the research question (Eliyah & Aslan, 2025) .

Results and Discussion

Agroecological Principles and Their Contribution to Sustainable Agriculture

Agroecology as a scientific and practical approach emphasises the integration of ecological principles into agricultural systems. This means that agriculture is not merely viewed as a food production activity, but as a complex ecosystem with interactions between soil, plants, animals, microorganisms, and humans. The basic principle is to utilise natural processes to create productive, resilient, and sustainable agricultural systems. Thus, agroecology rejects complete dependence on synthetic inputs and instead focuses on management based on ecosystem balance (Ranjan, 2024) .

One of the main principles of agroecology is diversification in agricultural systems. Diversification can be achieved through polyculture, agroforestry, crop rotation, or the integration of crops with livestock. Diverse systems provide many

benefits, ranging from increased soil fertility and natural pest control to ecosystem stability. Unlike monocultures, which are vulnerable to pest and disease attacks, diversification creates synergies between species that strengthen the resilience of agricultural systems. Diversification also increases the efficient use of resources such as light, water, and nutrients (Gonzalez-Abraham, 2023) .

The second prominent principle is efficiency in the use of local resources. Agroecology encourages farmers to utilise naturally available inputs, such as agricultural waste, manure, compost, and other organic materials. The use of local inputs not only reduces production costs but also maintains environmental balance through a continuous nutrient cycle. These efforts help reduce farmers' dependence on synthetic fertilisers and pesticides that have the potential to damage the environment (Sinclair, 2019) .

In addition to diversification and efficiency, agroecology also emphasises maintaining soil fertility through natural means. Soil is viewed as a living entity with diverse communities of microorganisms that play a crucial role in the nutrient cycle. Agroecology-based agriculture uses soil conservation techniques, cover cropping, crop rotation, and organic compost that can improve soil structure, water absorption capacity, and organic matter content. Healthy soil is the foundation of a sustainable agricultural system because it can support long-term productivity without damaging the ecosystem (Ewert, 2023) .

Another important aspect is ecological pest control. Agroecology does not rely on chemical pesticides but optimises ecological interactions to maintain pest population balance. For example, through the use of natural enemies, pest-repellent plants, or crop rotation techniques. This principle not only reduces input costs but also maintains environmental health and food safety. Additionally, biological control tends to be more stable and sustainable compared to the use of synthetic pesticides, which often lead to pest resistance (Hunter, 2019) .

The next principle is adaptation to local conditions. Agroecology encourages farmers to develop agricultural systems that align with local ecological, social, and cultural characteristics. Each region has unique soil, climate, crop types, and traditional practices that can form the basis for agroecology development. Thus, agroecology is not uniform, but rather highly contextual and flexible. This approach makes agroecology more acceptable to local communities because it is in line with traditional wisdom that has been passed down from generation to generation (Yulianto, 2016) .

Agroecology also incorporates the principles of social and ecological resilience. Resilience is characterised by the ability of an agricultural system to survive and recover from disturbances, whether in the form of climate change, pest attacks, or market shocks. Diverse, ecologically based systems that are closely connected to farming communities are more resilient to uncertainty. In the long term, this resilience is key to sustainability (Shukla, 2022) .

From an environmental perspective, agroecology makes a tangible contribution to achieving sustainable agriculture. By reducing the use of chemical pesticides, agroecology plays a role in protecting biodiversity, both in the soil and in the surrounding agricultural environment. Biodiversity is an important asset because it provides ecosystem services that support agriculture, such as pollination, nutrient cycling, and natural pest control (Paudel & Shrestha, 2022) . Thus, agroecology is not only productive but also contributes positively to the preservation of global ecosystems.

Another contribution to the environment is climate change mitigation and adaptation. Agroecological systems based on soil conservation and the use of organic fertilisers can increase carbon reserves in the soil. This helps reduce carbon emissions that contribute to global warming. In addition, crop-livestock diversification and integration enable farmers to be more adaptive to climate variability, so that food production is not overly disrupted by weather uncertainty (Rosati & Yadav, 2021) .

In the social dimension, agroecology also strengthens food sovereignty. Its principles enable farmers to produce food according to the needs of local communities without dependence on large-scale seed and agrochemical industries. Thus, farming communities gain greater space to determine the direction of their own food systems. Agroecology also emphasises inclusivity, namely the involvement of marginalised groups, women, and indigenous communities in building a fair agricultural system (Leippert & Koczberski, 2023) .

Another social benefit is increased community participation. Agroecology is often built through networks of farmers who share experiences, knowledge and best practices. This approach fosters solidarity and collaboration at the local level, which in turn strengthens collective capacity to adapt to challenges. By placing farmers at the centre, agroecology promotes empowerment, which is essential for sustainable development (Prabhu, 2022) .

Economically, the application of agroecology can increase production cost efficiency. The availability of cheap or even free local inputs, such as green manure, farmyard manure, and compost, helps farmers reduce their financial burden. In addition, agroecology also allows for diversification of income sources, for example through the management of food crops, horticulture, livestock, and non-timber forest products. This diversification not only increases income but also reduces the risk of crop failure due to dependence on a single commodity (Amekawa, 2010) .

However, the economic contribution of agroecology is not only short-term. In the long term, agroecology is more resistant to price fluctuations and imported inputs, and ensures production stability even in uncertain environmental conditions. Agriculture based on ecological principles promotes sustainable economic development because it does not incur external costs in the form of environmental damage that is usually borne by the wider community. In other words, agroecology also

reflects the principle of intergenerational justice in sustainability (Syafrianti & Zega, 2024) .

Overall, agroecological principles make a significant contribution to sustainable agriculture through three main pillars: environmental, social, and economic. Diversification, local input efficiency, soil fertility, biological control, and local adaptation form the ecological pillar. Food sovereignty, inclusivity, and farmer participation strengthen the social pillar. Meanwhile, cost efficiency, income diversification, and long-term stability reinforce the economic pillar. Thus, agroecology is not only a technical alternative but also a transformative strategy in realising a sustainable food system.

Supporting Factors and Challenges in Implementing Agroecology

The implementation of agroecology in sustainable agricultural practices cannot be separated from the accompanying social, economic, and policy conditions. Supporting factors and challenges are two important aspects that interact with each other in determining the success or failure of agroecology implementation. Understanding these two aspects is important so that agroecology development strategies can be designed appropriately and effectively in accordance with local and global contexts (Simtowe & Nelson, 2023) .

One of the main supporting factors is government policy support. Policies that facilitate farmers' access to agroecology training, financial facilities, and market protection are vital in encouraging the adoption of agroecology principles. In several countries, the government has issued subsidies and special incentives for organic and agroecological farming. These sustainability-oriented policies open up more space for farmers to try and develop agroecological practices more seriously (Siarudin, 2021) . In addition to policy, the role of communities and farmer organisations is crucial to the successful implementation of agroecology. Solid and mutually supportive communities can become a forum for learning and knowledge exchange between farmers. These organisations are also able to fight for the interests of their members to gain better market access and technical support. Through community networks, agroecological innovations and practices can spread more quickly and sustainably (Robinson, 2024) .

Another supporting factor is the existence of local wisdom and traditional knowledge that is deeply ingrained in farming communities. This wisdom often serves as the foundation for agroecology development, as its principles are not significantly different—preserving ecological balance and using resources wisely. With this understanding, the agroecology approach does not feel foreign and is easier to implement by farmers compared to concepts that are entirely new and culturally foreign (Martinez-Cruz, 2023) .

Access to education and technical training is also an equally important supporting factor. Enhancing farmers' capacity through extension and technical guidance from government agencies, universities, and non-governmental organisations

plays a significant role in improving farmers' understanding and practical skills. This training helps farmers understand the principles, techniques, and benefits of agroecology in depth so that they can apply them correctly and optimally (Aristya & Taryono, 2021) .

Environmentally friendly technologies and innovations also provide a positive boost. Examples include the use of agricultural tools that support erosion-free soil management, composting technology, and planting methods that improve water use efficiency. Technological innovations that are in line with agroecology principles enable farmers to implement more effective practices while minimising negative impacts on the environment (Swasono, 2023) .

Market support is another key factor determining the success of agroecology. A growing market for agroecological products at competitive prices can provide direct economic incentives to farmers. The availability of distribution networks and consumers who care about sustainable products creates an incentive to adopt agroecological principles. Without adequate markets, farmers are often reluctant or find it difficult to maintain these sustainable agricultural practices (Kalawawo, 2023) .

Conversely, the main challenge often faced is the dominance of the conventional agricultural paradigm, which is deeply rooted at both the policy and field practice levels. The culture of using chemical fertilisers and pesticides, the adoption of intensive technology, and the orientation towards mass production are difficult to change in a short period of time. This has led to resistance from various parties, especially farmers who are accustomed to the conventional system and are concerned about the risk of short-term yield declines (Fitri & Usni, 2024) .

The next challenge is the lack of access for farmers to resources and technologies that support agroecology. Not all farmers have the financial capacity or adequate technological networks to optimally implement agroecological techniques. For example, access to high-quality local seeds, composting tools, or environmentally friendly irrigation is often limited. These limitations hinder farmers' potential for innovation and adaptation to agroecological principles (Faisol & Atekan, 2020) .

Inadequate market access is also a serious obstacle. Agroecological products often struggle to find a place in wider markets due to a lack of promotion, organic certification, and competitive pricing compared to conventional products. This leads to unstable incomes for farmers and reduces their motivation to maintain agroecological practices (Kocira, 2020) . In addition, there are also limitations in terms of research and applied innovation support. Much agroecology research still focuses on conceptual aspects and has not yet produced many appropriate technologies that can be directly adopted by farmers. These research limitations make it difficult for some farmers to deal with the specific conditions of their farms. In fact, more adaptive and integrated research is essential to address local climate, soil, and socio-cultural variability (Nikezic, 2022) .

The lack of consumer awareness and knowledge about agroecological products also poses a market challenge. Consumers often do not understand the benefits of sustainable products and tend to choose cheaper products, even if they are produced using conventional methods. This results in weak market demand, meaning that farmers do not get the added value from their more environmentally friendly and sustainable practices (Susanti et al., 2024) .

Socio-cultural challenges also arise from the perceptions and attitudes of farmers themselves. Many farmers remain sceptical about the effectiveness of agroecology or feel threatened by changes to the farming methods they have practised for years. This attitude is reinforced by uncertainty about production outcomes and the perceived higher economic risks of abandoning familiar conventional practices (Hidayat et al., 2023) .

In some cases, power imbalances in the agricultural supply chain pose a serious obstacle. Farmers often find themselves in a weak bargaining position vis-à-vis large traders, seed companies, or agricultural input distributors. This situation makes it difficult for farmers to control prices and obtain fair profits, thereby hindering their efforts to maintain agroecological practices. To overcome these complex challenges, a strengthening strategy involving multi-stakeholder collaboration is needed (Martinez-Abraham, 2023) . Governments, academics, NGOs, market actors, and farmer communities must work together to build a comprehensive support system. This strategy includes improving education and training, providing economic incentives, developing strong markets, and conducting more adaptive and applicable research. This holistic approach is crucial to ensuring the sustainability and success of agroecology implementation on a large scale (Bharucha & Prabhu, 2025) .

Conclusion

The findings of this study conclude that: first, agroecology is an agricultural approach that integrates ecological principles holistically into food production systems. Key principles such as crop diversification, utilisation of local resources, maintenance of soil fertility, and biological control contribute significantly to improving environmental sustainability. Agroecology not only supports the conservation of biodiversity and nutrient cycles, but also helps mitigate climate change through carbon storage and adaptation to climate variability.

Secondly, it explains that the application of agroecology also provides important social and economic benefits. This concept strengthens food sovereignty and the participation of farming communities, promoting inclusiveness and the empowerment of vulnerable groups. Economically, agroecology helps reduce production costs through the use of local inputs and diversification of agricultural enterprises, increasing the long-term income stability of farmers. This makes agroecology a holistic strategy that is in line with the principles of sustainable development.

Thirdly, it shows that the successful implementation of agroecology is largely determined by the synergy of supporting factors and existing challenges. Government policy support, the active role of farming communities, access to training, and adequate markets are the main pillars of success. On the other hand, the dominance of the conventional agricultural paradigm, limited access to resources, narrow markets, and cultural resistance are significant obstacles. Therefore, a comprehensive multi-stakeholder collaborative strategy is needed to strengthen the development of agroecology and support the transition to sustainable agriculture.

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