British Journal of Agroecology and Environmental Studies

DOI: 10.61424/bjaes
Journal Homepage: www.bluemarkpublishers.com/index.php/BJAES

BJAES
BLUEMARK PUBLISHERS

| RESEARCH ARTICLE

A Review on the Role of Agroecology in Achieving Sustainable Development Goals

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| ABSTRACT

This review explores the role of agroecology in advancing the United Nations Sustainable Development Goals (SDGs), with particular emphasis on food security, environmental sustainability, and social equity. Agroecology, as both a scientific approach and a set of practices, integrates ecological principles into agricultural systems, promoting resilience, resource efficiency, and biodiversity conservation. The review synthesizes existing literature to highlight how agroecological practices contribute to key SDGs, including zero hunger (SDG 2) through enhanced food sovereignty and nutrition, climate action (SDG 13) via mitigation and adaptation strategies, and life on land (SDG 15) through soil health and biodiversity preservation. Moreover, agroecology fosters inclusive rural development and gender equality (SDGs 1, 5, and 10) by empowering smallholder farmers and marginalized groups. While evidence shows that agroecology offers a viable pathway to sustainable and just food systems, challenges such as policy misalignment, limited institutional support, and knowledge gaps hinder its broader adoption. The study concludes that scaling up agroecology requires supportive policy frameworks, investment in participatory research, and stronger linkages between local practices and global sustainability agendas. By aligning ecological processes with socio-economic objectives, agroecology emerges as a transformative strategy for achieving multiple, interrelated SDGs.

| KEYWORDS

Agroecology, SDGs, Social equity**,** Biodiversity conservation, Climate action.

| ARTICLE INFORMATION

ACCEPTED: 19 July 2025 **PUBLISHED:** 19 September 2025 **DOI:** 10.61424/bjaes.v2.i1.433

1. Introduction

The pursuit of sustainable development has become a global priority in the face of mounting environmental challenges, socio-economic inequalities, and the urgent need to ensure food and livelihood security for a growing population. In 2015, the United Nations (UN) adopted the 17 Sustainable Development Goals (SDGs) as a blueprint for addressing interconnected global challenges by 2030. These goals span critical areas such as poverty reduction, food security, environmental sustainability, climate action, and social equity (Thakur, 2022). Achieving these goals requires transformative approaches that integrate ecological, social, and economic dimensions of development. One promising approach that has gained recognition in recent years is agroecology.

Agroecology is more than a set of farming practices; it is a holistic framework that applies ecological principles to agricultural systems while incorporating social justice, cultural traditions, and local knowledge (Altieri, 2020). It emphasizes biodiversity, resource efficiency, resilience, and equity, making it a multidimensional approach aligned with the core values of sustainable development. Unlike conventional agricultural systems, which are often criticized

for contributing to soil degradation, biodiversity loss, and greenhouse gas emissions, agroecology offers pathways for creating sustainable food systems that contribute to multiple SDGs simultaneously.

The role of agroecology in achieving the SDGs is increasingly evident in both academic and policy discourses. For instance, its contribution to SDG 2 (Zero Hunger) lies in enhancing food security through diversified production and sustainable intensification (Ching, 2018). Similarly, agroecological practices support SDG 13 (Climate Action) by promoting carbon sequestration, reducing dependency on synthetic inputs, and strengthening adaptation to climate variability. Beyond environmental dimensions, agroecology contributes to SDG 1 (No Poverty) and SDG 10 (Reduced Inequalities) by empowering smallholder farmers, strengthening rural economies, and fostering inclusive governance. These synergies demonstrate that agroecology is not merely an agricultural alternative but a strategic tool for sustainable development.

However, despite its potential, the mainstreaming of agroecology faces several challenges, including limited policy support, market barriers, and knowledge gaps. There remain debates on its scalability and integration into global food systems, especially given the pressures of feeding a growing population (Wezel, 2020). Thus, a critical review of the role of agroecology in advancing the SDGs is necessary to highlight its strengths, identify gaps, and inform strategies for its broader adoption.

This study, therefore, reviews the role of agroecology in achieving the Sustainable Development Goals by synthesizing evidence from existing literature. It explores the linkages between agroecological principles and different SDGs, highlights case studies where agroecology has been instrumental in advancing sustainability, and discusses the challenges and opportunities for scaling up agroecological transitions (Si, 2021). By doing so, the paper aims to provide insights into how agroecology can serve as a transformative pathway towards the realization of the 2030 Agenda for Sustainable Development.

2. Methodology

2.1 Research Design

This study employed a systematic review design to examine the role of agroecology in achieving the Sustainable Development Goals (SDGs). The review approach was chosen because it enables the integration of existing scholarly findings, policy documents, and empirical evidence, offering a comprehensive understanding of agroecology's contributions across different contexts. Emphasis was placed on synthesizing multidisciplinary perspectives, given that agroecology intersects with agricultural, environmental, economic, and social dimensions of sustainability.

2.2 Literature Search Strategy

A structured search of peer-reviewed journal articles, reports, and policy papers was conducted from multiple databases, including Scopus, Web of Science, ScienceDirect, and Google Scholar. Additional grey literature from international organizations such as the Food and Agriculture Organization (FAO), United Nations Development Programme (UNDP), and World Bank was also considered to capture policy-level insights. Search terms included combinations of keywords such as *"agroecology," "sustainable development goals," "agriculture sustainability," "food systems," "climate resilience,"* and *"biodiversity conservation."* Boolean operators (AND, OR) were applied to refine the search results.

2.3 Inclusion and Exclusion Criteria

To ensure relevance and quality, specific criteria guided the selection of studies. Only articles published between 2000 and 2025 were included, as this period captures the growing global discourse on sustainability and the post-2015 development agenda. Publications had to explicitly discuss agroecology and its linkages to one or more SDGs. Excluded materials comprised studies lacking empirical or conceptual connections to agroecology, non-English publications, and duplicates.

2.4 Data Extraction and Analysis

The selected literature was systematically reviewed, and key information was extracted, including the study context, objectives, methodologies, and main findings. Special focus was given to mapping agroecological principles against relevant SDGs, such as food security (SDG 2), climate action (SDG 13), responsible consumption and production (SDG 12), and life on land (SDG 15). A thematic analysis approach was employed to identify recurring themes, synergies, and trade-offs, thereby enabling an integrative interpretation of evidence across studies.

2.5 Quality Assurance

To enhance the credibility and reliability of the review, a transparent and replicable procedure was followed. Studies were assessed based on methodological rigor, citation impact, and relevance to agroecology and sustainable development. Cross-validation was undertaken by comparing findings across multiple sources to ensure consistency. Additionally, policy documents were critically appraised to highlight practical applications of agroecological principles in achieving the SDGs.

2.6 Limitations of the Methodology

While the review design provided a comprehensive understanding of the role of agroecology in advancing the SDGs, some limitations exist. The restriction to English-language publications may have excluded valuable regional perspectives. Similarly, the reliance on published literature may have overlooked grassroots knowledge and indigenous practices that are integral to agroecology. Despite these limitations, the methodology ensures a robust and balanced synthesis of available evidence.

3. Findings and Discussion

3.1 Agroecology and Food Security (SDG 2: Zero Hunger)

Agroecology has emerged as a vital approach to achieving food security by integrating ecological principles with agricultural practices. The findings from reviewed studies suggest that agroecology strengthens the resilience of farming systems, improves food availability, and enhances access to diverse and nutritious diets (Niggli, 2023). In line with the objectives of SDG 2 (Zero Hunger), agroecological practices address both the quantity and quality of food production while ensuring long-term sustainability.

3.1.1 Enhancing Agricultural Productivity

One of the most consistent findings in the literature is that agroecological practices, such as intercropping, crop rotation, and organic soil management, contribute to sustainable increases in agricultural productivity. For example, a study by Cao (2023) found that diversified organic systems reduced yield gaps compared to conventional monocultures, particularly when ecological intensification techniques like nitrogen-fixing legumes and compost use were applied. Similarly, Lampkin (2015) highlighted that traditional agroecological systems in Latin America, such as the milpa (maize-beans-squash) system, not only maintain stable yields but also enhance soil fertility through natural nutrient cycling. These findings emphasize that productivity gains under agroecology are not achieved through chemical intensification but by harnessing ecological interactions, thereby reducing dependence on synthetic inputs and preserving environmental health.

3.1.2 Diversification of Food Systems

Diversification stands out as a key pathway through which agroecology contributes to food and nutrition security. By promoting polycultures, agroforestry, and integrated crop-livestock systems, agroecology ensures access to a variety of food sources and reduces reliance on monocultures vulnerable to pests, diseases, and market volatility. Evidence from sub-Saharan Africa demonstrates that households practicing agroforestry and mixed farming are more likely to have access to nutrient-dense foods such as fruits, vegetables, and animal products (Schwarz, 2022). In Kenya, the adoption of push-pull technology, which integrates maize with Desmodium and Napier grass, has not only suppressed pests like the fall armyworm but also provided livestock fodder, improving both food and income security (Sethuraman, 2021). Such systems contribute to balanced diets, thereby addressing hidden hunger caused by micronutrient deficiencies. The emphasis on diversity also aligns with findings by Cornell (2023), which stress that diversified food systems are more sustainable and equitable than input-intensive monocultures.

3.1.3 Reducing Vulnerability to Food Crises

Agroecology also plays a critical role in reducing household and community vulnerability to food crises triggered by climate shocks, pest outbreaks, and market instability. Practices such as soil and water conservation, seed saving, and community seed banks enhance adaptive capacity by ensuring resource availability during periods of stress. For instance, studies from Cuba's food system transformation in the 1990s showed that when chemical inputs became scarce due to economic collapse, agroecological networks enabled farmers to sustain production and avoid widespread famine (Kerr, 2022). Similarly, diversified farms in Central America demonstrated greater resilience to hurricanes compared to conventional farms, with higher soil retention, less erosion, and faster recovery of yields (Bernard, 2017). These findings align with Snapp (2021) report to the UN, which emphasized agroecology as a strategy for climate-resilient food security. By reducing dependence on external inputs and markets, agroecology strengthens local autonomy and ensures that households are better protected against systemic shocks.

3.2 Agroecology and Environmental Sustainability (SDGs 13, 14, 15)

This section synthesizes evidence on how agroecological approaches affect environmental sustainability—focusing on soil and land restoration, biodiversity conservation, and climate change mitigation/adaptation—and relates those outcomes to SDG 13 (Climate Action), SDG 14 (Life Below Water) and SDG 15 (Life on Land) (Shahmohamadloo, 2021). Across the literature reviewed, agroecology consistently shows positive environmental outcomes relative to conventional, input-intensive systems, though magnitude and consistency vary by context (crop, landscape, socioecological conditions) and timescale.

3.2.1 Soil Fertility and Land Restoration

A strong and recurring finding is that agroecological practices—crop rotation, intercropping, cover cropping, reduced/no-tillage, organic amendments (compost, manure), agroforestry, and integrated crop–livestock systems—improve soil organic matter, aggregate stability, and other indicators of soil health over conventional monocultures that rely heavily on synthetic fertilizers (Mottet, 2020). Several long-term comparisons show increases in soil organic carbon (SOC) and in water-holding capacity where organic inputs and diverse rotations are used, with associated reductions in runoff and erosion. Land restoration projects that incorporate agroecological principles (e.g., reintroducing trees, perennial cover and native species) often reverse degradation trends on marginal lands and reduce the rate of desertification.

Field-level case studies from smallholder systems show measurable SOC gains within 3–10 years after adopting agroecological practices, especially when combined with agroforestry. Conservation agriculture components (residue retention + cover crops) tend to show quicker reductions in erosion and improvements in infiltration than single-practice interventions (Wezel. 2014). Meta-analyses reported in the review indicate that while yields under some agroecological systems can initially be lower than under high-input conventional systems, yield stability and soil productivity tend to be higher in the medium-to-long term as soil fertility builds—an important trade-off for sustainability and SDG 2 (Zero Hunger) linked back to soil outcomes.

Improved soil health under agroecology supports SDG 15 by enhancing land productivity and resilience, lowering the need for external chemical inputs, and decreasing erosion-driven sedimentation that affects freshwater and coastal systems (linking to SDG 14) (Nelles, 2021). However, benefits are context-dependent: in severely degraded soils, recovery can take years and requires enabling factors (access to organic amendments, local knowledge, supportive policy). Scaling restoration therefore demands investments in farmer training, organic matter supply chains, and tenure security to realize long-term SOC gains and to avoid rebound effects (e.g., short-term yield drops that push farmers back to destructive practices).

3.2.2 Biodiversity Conservation

Agroecological systems tend to conserve and often enhance on-farm biodiversity (crop genetic diversity, associated weeds and wild plants, beneficial insects, birds and soil biota) relative to simplified monocultures. Practices such as intercropping, hedgerow planting, field margin management, and agroforestry create habitat heterogeneity that supports pollinators, natural enemies of pests, and other taxa (Pandey, 2023). At landscape scale, mosaics of

agroecological farms, semi-natural habitats, and corridors contribute to greater species richness and functional diversity.

Empirical comparisons in the review show higher pollinator abundance and diversity on farms using flower strips, diversified cropping and reduced pesticide regimes. Integrated pest management that emphasizes biological control often reduces pesticide applications while maintaining pest suppression through enhanced predator populations (Francis, 2017). Studies comparing organic/agroecological farms with conventional counterparts frequently report higher species richness for non-crop organisms (soil microbes, arthropods, birds), though some mobile species respond at landscape rather than single-farm scales.

Conventional intensive systems—characterized by large monocultural blocks, heavy pesticide use, and removal of non-crop habitats—consistently score lower on biodiversity metrics (Montagnini, 2018). The review highlights, however, that biodiversity outcomes in agroecology are not uniform: some practices (e.g., certain agroforestry designs) produce larger biodiversity gains than minimal diversification alone, and highly managed "ecological intensification" can still fall short if landscape connectivity and non-cultivated refuges are absent.

Biodiversity benefits contribute directly to SDG 15 and indirectly to SDG 2 and 13 by sustaining ecosystem services (pollination, pest control, nutrient cycling) that underpin productive and resilient food systems. For coastal and marine systems (SDG 14), reduced agrochemical runoff from agroecological systems helps limit eutrophication and habitat degradation (Kumar, 2021). Policy and planning should therefore promote landscape-level coordination (protecting corridors and wetlands), incentives for habitat-friendly practices, and monitoring programs that track both species richness and functional outcomes, because biodiversity alone is not a full proxy for ecosystem service delivery.

3.2.3 Climate Change Mitigation and Adaptation

Agroecology contributes to both mitigation (carbon sequestration, reduced greenhouse gas (GHG) emissions) and adaptation (enhanced system resilience to climate variability). Practices that build SOC—agroforestry, cover crops, reduced tillage, organic amendments—store carbon in biomass and soils, while integrated systems that lower synthetic nitrogen use can reduce nitrous oxide emissions (Bezner Kerr, 2022). Furthermore, diversified systems and landscape heterogeneity improve adaptive capacity by spreading risk (e.g., different crop responses to drought), improving water retention, and stabilizing yields under extreme weather.

Field and regional studies included in the review report SOC increases and above-ground carbon accumulation in agroforestry systems, with co-benefits for biodiversity and livelihoods. Life cycle assessments comparing agroecological and conventional pathways typically show lower carbon footprints per unit area for agroecological systems; however, carbon footprints per unit product vary depending on yield differences and local practices (Waldron, 2017). Adaptation evidence includes documented reductions in crop failure rates and quicker recovery after droughts on diversified farms, due to deeper rooting systems, shading from trees, and improved soil moisture.

Agroecology aligns with the objectives of the Paris Agreement by offering bottom-up, land-based mitigation options and by strengthening Nationally Determined Contributions (NDCs) when countries incorporate agroecological and regenerative practices into land-use planning (Ching, 2018). The review highlights that agroecology's co-benefits—biodiversity, soil health, water regulation—make it attractive for integrated climate–biodiversity strategies, but also notes the need for rigorous measurement, reporting, and verification (MRV) frameworks to credibly include agroecological sequestration in national accounting.

While the potential for sequestration is real, the review cautions against overstating mitigation without careful accounting: SOC gains can plateau or reverse if practices are not maintained, and permanence is an issue. Moreover, mitigation per unit of food can be lower in systems with reduced yields unless yield gaps are closed via agroecological intensification (Si, 2021). For adaptation, success depends on socioinstitutional factors—farmers'

access to diverse seed, credit, extension, and secure land tenure. Integrating agroecology into NDCs and climate finance instruments requires standardized indicators, incentives for smallholders, and safeguards to ensure co-benefits for biodiversity and food security rather than commodifying carbon at the expense of local needs.

3.3 Agroecology and Socio-Economic Dimensions (SDGs 1, 8, 10)

Agroecology extends beyond ecological outcomes to address pressing socio-economic challenges such as poverty reduction, livelihood improvement, decent work, and social equity. The findings indicate that agroecological practices contribute to strengthening rural economies and fostering inclusive growth by promoting sustainable income opportunities, creating employment, and empowering marginalized groups (Cao, 2023). These outcomes are directly linked to SDG 1 (No Poverty), SDG 8 (Decent Work and Economic Growth), and SDG 10 (Reduced Inequalities).

3.3.1 Farmer Livelihoods and Poverty Reduction

Evidence shows that agroecology enhances farmer livelihoods by reducing dependency on external inputs and promoting diversified production systems that provide both subsistence and marketable outputs. For example, smallholders practicing agroecological techniques such as intercropping and integrated pest management in sub-Saharan Africa reported reduced production costs and more stable incomes due to increased resilience against climatic shocks (Lampkin, 2015). Similarly, studies in Latin America demonstrated that community-based agroecological systems improved household food security while generating surplus income from organic produce sold in local markets (Kerr, 2022).

Agroecology also plays a crucial role in poverty alleviation by mitigating risks associated with monoculture farming and volatile global markets. Diversification through agroecology provides farmers with multiple revenue streams, such as crop sales, livestock products, and value-added goods like honey or dairy. This diversified livelihood portfolio acts as a safety net, especially for rural households vulnerable to poverty. These findings align with Snapp (2021), which emphasized agroecology's role in building resilient livelihoods that directly contribute to SDG 1.

3.3.2 Employment and Local Economies

The transition towards agroecological systems has been found to create employment opportunities and revitalize local economies. Agroecology is often more labor-intensive compared to conventional farming, especially in areas such as soil fertility management, crop diversification, and post-harvest value addition. For instance, research in West Africa revealed that agroecological practices increased on-farm labor demand, providing jobs for rural youth who would otherwise migrate to urban areas (Mottet, 2020).

In addition, agroecology strengthens local markets through short supply chains, farmers' cooperatives, and community-based enterprises. Direct marketing initiatives such as farmers' markets, participatory guarantee systems (PGS), and farm-to-school programs not only enhance farmers' income but also stimulate local economies by retaining wealth within communities. Evidence from Brazil's agroecological movement shows that PGS-certified farmers gained market access while fostering consumer trust, creating a cycle of local economic resilience (Nelles, 2021). These findings illustrate how agroecology advances SDG 8 by creating decent work opportunities and fostering sustainable local economies.

3.3.3 Social Equity and Gender Inclusion

Agroecology also contributes to addressing structural inequalities by empowering marginalized groups, including women, youth, and indigenous communities. Women in particular benefit from agroecological systems that emphasize diverse, small-scale, and locally oriented production. In East Africa, women farmers engaged in agroecological seed banks reported greater decision-making power in household resource allocation and community leadership (Francis, 2017). Similarly, youth-led agroecology initiatives in Asia demonstrated how agroecology can be a viable livelihood pathway for younger generations, offering alternatives to migration and unemployment.

Moreover, agroecology promotes social equity by fostering collective action and knowledge sharing. Community-based organizations and farmer cooperatives provide inclusive platforms where marginalized voices are heard, thereby reducing social inequalities. This aligns with SDG 10, as agroecology creates opportunities for equitable participation in agricultural decision-making and market access. Studies by Kumar (2021) emphasized that agroecology is not only a farming practice but also a social movement that champions equity and justice, particularly for historically disadvantaged populations.

3.4 Agroecology and Policy / Institutional Frameworks (SDGs 16 & 17)

3.4.1 Policy support and governance

Our review shows that enabling policy environments are a decisive factor in whether agroecological approaches move from pockets of practice into systemic transformation (Waldron, 2017). Countries with explicit, coherent national frameworks — most notably Brazil's National Policy for Agroecology and Organic Production (PNAPO) — demonstrate greater coordination across ministries, more sustained financing for farmer-led initiatives, and clearer market and institutional pathways for agroecological products (Bezner Kerr, 2022). PNAPO's participatory design, multi-sectoral mandates and linkages to public procurement programs have been repeatedly highlighted as a policy model that helped scale local innovations and integrate agroecology into rural development strategies.

By contrast, many national and regional policy arenas remain dominated by industrial-agriculture paradigms (subsidies for agrochemicals, seed laws favoring uniform certified varieties, trade rules privileging export monocultures) (Montagnini, 2018). These policy settings create structural barriers to agroecology: they reduce the competitiveness of diversified smallholder systems, limit access to locally adapted seeds, and channel research and extension toward input-intensive packages rather than farmer knowledge and ecological approaches (Pandey, 2023). IPES-Food and other analyses find that without deliberate policy shifts (reallocating subsidies, creating incentives for diversification, revising procurement rules), agroecology risks being sidelined or limited to niche markets.

In summary, our evidence indicates that (1) explicit national policies and cross-sectoral governance mechanisms greatly facilitate agroecology adoption, and (2) industrial-agriculture policy legacies are a recurrent barrier that must be actively restructured to create enabling environments.

3.4.2 Research, knowledge, and education systems

Findings from the literature and documented case studies consistently emphasize the centrality of participatory research, farmer-to-farmer knowledge exchange, and the reorientation of formal research and training systems (Wezel, 2014). The FAO's Scaling-Up Agroecology initiative and HLPE reviews both highlight that participatory action-research, farmer field schools, and community seed networks produce locally relevant innovations and faster adoption than top-down research models. Where extension services adopted facilitation and co-learning roles (rather than simply delivering inputs), uptake and retention of agroecological practices were higher.

Concrete examples include successful Farmer Field School networks and women-led volunteer extension programs (reported in several country cases) that increased skills in pest management, crop diversification, and post-harvest handling — outcomes that formal curricula alone did not achieve (Shahmohamadloo, 2021). The IPES-Food case studies show that investing in local knowledge systems not only improves on-farm outcomes (productivity, resilience) but also strengthens social capital and collective governance that underpin longer-term transitions. Our review therefore finds that integration of agroecology into university curricula, vocational training and public extension is necessary but must be paired with mechanisms that fund and legitimize farmer knowledge as research input.

However, barriers persist: research funding streams and academic incentives still favor short-term, productivity-centred experiments and technologies that are easy to publish but less relevant to complex, place-based agroecological systems (Bernard, 2017). Changing these incentive structures (including tenure and evaluation

criteria for researchers) emerged repeatedly in the literature as key to scaling agroecology beyond demonstration plots.

3.4.3 International cooperation and partnerships

International organizations, multilateral initiatives, and NGOs play a catalytic role in legitimizing agroecology, convening actors, and providing technical and financial support. FAO's Scaling-Up Agroecology Initiative is an example of an international program that has framed agroecology in the language of the SDGs, promoted the FAO's "10 Elements of Agroecology," and provided a platform for knowledge exchange across regions (Schwarz, 2022). Such global partnerships can accelerate mainstreaming by combining normative guidance, technical assistance and policy advice.

NGOs and transnational networks (e.g., farmer movements documented by IPES-Food) have been especially effective at creating horizontal partnerships — linking grassroots experimentation with policy advocacy. These alliances can create demand for policy reform (public procurement, social protection, and market access) while also demonstrating models of inclusive governance (Cornell, 2023). Our review finds multiple examples where international–local partnerships enabled scaling: international programs supplied seed funding and convening power while local organizations provided contextual knowledge and sustained community engagement.

At the same time, tensions and conflicts emerge within international policy spaces. Several analyses note that mainstreaming agroecology into global agendas sometimes leads to conceptual dilution (equating agroecology with vaguely defined "sustainable intensification" or regenerative claims) or to competition for funding with more technology-driven, private-sector led approaches (Sethuraman, 2021). These dynamics can create trade-offs: international cooperation can either bolster farmer-led agroecology if it supports local institutions and rights, or it can distort agendas if funding privileging private certification or market access replaces public investment in commons (seeds, extension, local markets) (Niggli, 2023). Our synthesis therefore stresses that international partnerships must be explicit about principles (rights, equity, food sovereignty) to avoid perverse outcomes and to align with SDG 16 (inclusive institutions) and SDG 17 (partnerships for the Goals).

3.5 Integration of Agroecology with Sustainable Development Goals

Agroecology demonstrates significant potential as an integrative framework that advances multiple Sustainable Development Goals (SDGs) in tandem. By linking ecological processes with socio-economic and governance dimensions, agroecology provides a holistic approach to addressing hunger, climate change, inequality, and biodiversity loss (Thakur, 2022). The findings reveal that agroecology's multi-dimensional nature is both its strength and its challenge—it fosters synergies across goals but also encounters trade-offs that require careful navigation.

3.5.1 Synergies Across Multiple SDGs

One of the most important findings is the capacity of agroecology to generate co-benefits across food security, environmental sustainability, and social equity. For example, the integration of crop diversification and agroforestry enhances household nutrition (SDG 2), contributes to soil regeneration and carbon sequestration (SDG 13, 15), and provides smallholder farmers with diversified income streams, thereby reducing poverty (SDG 1) and inequality (SDG 10). Studies in Latin America and Sub-Saharan Africa show that agroecological farming systems often outperform monocultures in terms of resilience to climate shocks while supporting local markets and community-based food systems (Wezel, 2020).

Frameworks such as the "nexus approach" highlight how agroecology serves as a bridge among food, water, energy, and biodiversity systems, creating synergies across SDGs (Altieri, 2020). For instance, organic rice–fish systems in Southeast Asia improve yields while reducing pesticide use, simultaneously supporting SDG 2 (Zero Hunger), SDG 14 (Life Below Water), and SDG 12 (Responsible Consumption and Production). This evidence suggests that agroecology offers a systemic pathway for achieving integrated progress on the 2030 Agenda.

3.5.2 Trade-offs and Challenges

Despite its synergetic potential, agroecology also faces significant trade-offs and structural barriers. One key challenge is the perception of yield gaps compared to conventional high-input agriculture. While studies indicate that diversified agroecological systems often provide higher resilience and long-term productivity, short-term comparisons sometimes show lower yields for staple crops, creating tensions with food security objectives (Wezel, 2020).

Another barrier is limited market access. Smallholders practicing agroecology often struggle to compete in globalized food markets dominated by industrial agriculture. Without supportive infrastructure, certification systems, and fair pricing mechanisms, farmers may find it difficult to sustain agroecological practices (Sethuraman, 2021). Policy conflicts also emerge where subsidies disproportionately favor chemical fertilizers and monocultures, undermining agroecological adoption (Snapp, 2021).

In addition, cultural and institutional inertia can hinder transformation. For instance, extension services in many countries remain biased toward input-intensive models, providing little technical support for agroecological innovations (Mottet, 2020). These challenges highlight the need for systemic change in agricultural governance, research priorities, and market structures.

3.5.3 Future Prospects and Pathways

Looking ahead, scaling up agroecology requires multi-level strategies that address policy, research, and practice simultaneously. Policy frameworks need to shift toward integrated support systems, including subsidies for ecosystem services, participatory research, and investment in local food markets (Pandey, 2023). International initiatives, such as the UN Food and Agriculture Organization's (FAO) 10 Elements of Agroecology, provide useful pathways for aligning national strategies with SDGs.

Research gaps remain around measuring the long-term economic benefits of agroecology, especially in comparison with conventional farming. More evidence is needed on how agroecology contributes to gender equality (SDG 5), urban–rural linkages (SDG 11), and global partnerships (SDG 17) (Montagnini, 2018). Pathways for scaling up also involve leveraging digital tools for farmer knowledge exchange, strengthening farmer cooperatives, and embedding agroecology into climate adaptation policies.

The future prospects are promising if agroecology is recognized not merely as a farming technique but as a paradigm shift toward sustainability. By embedding agroecology within food system governance and aligning it with multiple SDGs, the world can move closer to a just and resilient transition (Waldron, 2017).

4. Conclusion

This review has demonstrated that agroecology provides a holistic and transformative pathway toward achieving the Sustainable Development Goals (SDGs). By integrating ecological principles into agricultural systems, agroecology not only enhances food security (SDG 2) through diversified and resilient production systems but also supports environmental sustainability (SDGs 13, 14, and 15) by reducing dependency on chemical inputs, conserving biodiversity, and mitigating climate change. Furthermore, the socio-economic dimensions of agroecology highlight its potential to reduce poverty (SDG 1), create decent work opportunities (SDG 8), and address inequalities (SDG 10), particularly in rural communities where smallholder farmers are central actors.

The analysis also reveals that the effectiveness of agroecology depends on supportive policy and institutional frameworks (SDGs 16 and 17). Strong governance, participatory decision-making, and multi-stakeholder partnerships are critical for scaling up agroecological practices and ensuring their long-term impact. Importantly, agroecology is not confined to a single SDG but rather cuts across multiple goals, creating synergies that address food, environmental, social, and governance challenges in an integrated manner.

In conclusion, agroecology emerges as a multidimensional approach that aligns with the principles of sustainability, resilience, and inclusivity at the heart of the 2030 Agenda. However, its full potential can only be realized through increased investment in research, knowledge co-creation with farmers, supportive policies, and global collaboration. Future efforts should focus on scaling up agroecological practices, strengthening institutional support, and fostering innovative partnerships that bridge science, practice, and policy. By doing so, agroecology can contribute meaningfully to a more just, sustainable, and food-secure world.

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