



Organic farming for sustainable agriculture: A systematic literature review of production practices, benefits and challenges

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Abstract

Organic farming has received increasing attention as a potential pathway toward more sustainable agricultural production, yet evidence regarding its environmental, productive, economic and social outcomes remains diverse. This systematic literature review examines the major dimensions of organic farming and their implications for sustainable agriculture. The review synthesizes 44 selected studies covering production practices and diversification, soil health and carbon, biodiversity, yield and yield stability, environmental and greenhouse-gas impacts, food quality, economic performance, farmer adoption, food security, social sustainability and life-cycle assessment. The findings indicate relatively consistent evidence of benefits associated with soil biological activity, soil quality, biodiversity and selected environmental indicators. However, productivity outcomes are more context dependent. Yield differences between organic and conventional systems vary according to crop type, climate, soil conditions, diversification and farm management. Economic viability is similarly influenced by production costs, labour, certification, market premiums and market access. The review also highlights the importance of farmer knowledge, extension services, institutional support and appropriate market infrastructure in facilitating adoption and long-term transition to organic production. Evidence concerning food security and social sustainability remains more heterogeneous and requires greater attention to local farming and socioeconomic conditions. Overall, the review indicates that organic farming should not be evaluated through a single indicator or certification status. Its contribution to sustainable agriculture depends on the interaction of ecological, productive, economic and institutional factors. Future research should therefore adopt integrated, long-term and context-specific approaches that combine environmental performance, productivity, economic viability and social outcomes.

Keywords: Organic farming, sustainable agriculture, soil health, biodiversity, yield sustainability, environmental impacts, farmer adoption, food security, agro-ecology, life-cycle assessment

Introduction

1. Background and Rationale

Agriculture is expected to meet growing food requirements while simultaneously conserving natural resources, maintaining soil quality, protecting biodiversity and reducing environmental pressures. Within this context, organic farming has received considerable attention as an agricultural approach that emphasizes ecological processes, biological nutrient cycling, crop diversification and reduced reliance on synthetic agricultural inputs. The sustainability of organic farming, however, cannot be understood through a single indicator because agricultural systems generate interconnected environmental, production and socioeconomic outcomes. A global review by Meemken and Qaim (2018) ^[23] noted that organic agriculture can provide environmental benefits, but its performance differs depending on whether outcomes are assessed per unit of land or per unit of agricultural output.

One of the major areas in which organic farming has attracted research attention is biodiversity. Organic management generally avoids or substantially reduces the use of synthetic pesticides and inorganic fertilizers and commonly incorporates more diverse crop rotations. Evidence from meta-analytical research indicates that organic farming is frequently associated with greater species richness and abundance than conventional farming, although

the magnitude of the effect varies among organism groups, crops and landscape conditions (Bengtsson *et al.*, 2005) ^[4]. More recent hierarchical meta-analysis similarly found positive biodiversity effects but demonstrated that these effects are influenced by land-use intensity, crop type and the organisms being studied. The same research also identified a geographical concentration of evidence in Europe and North America, indicating the need for greater investigation in tropical, subtropical and other comparatively under-researched agricultural regions (Tuck *et al.*, 2014) ^[37].

Soil health represents another important dimension of organic agriculture. Organic production practices can influence soil biological activity, nutrient cycling, organic matter and microbial communities over time. These processes are particularly relevant to sustainable agriculture because soil quality provides the foundation for long-term agricultural productivity. At the same time, the benefits of organic management are not necessarily uniform across locations because soil characteristics, climate, crop type, duration of organic management and farm-level practices can modify outcomes. Consequently, organic farming is increasingly being examined as a management system whose performance depends on the interaction between production practices and local ecological conditions rather than simply as a substitute for conventional inputs.

Productivity remains one of the most debated aspects of organic agriculture. Comparative evidence has generally reported lower average yields in organic systems, although substantial variation exists across crops and production environments. The yield question is therefore more complex than a simple comparison of average output. Differences in crop diversification, soil fertility, climate, management practices and resource availability can influence the size of the yield difference. Similarly, environmental performance can change depending on whether impacts are calculated per hectare or per unit of agricultural product. Meemken and Qaim (2018) ^[23] emphasize this distinction in their global assessment of organic agriculture, food security and environmental outcomes.

The sustainability debate also extends beyond environmental and production outcomes to economic and food-security considerations. Organic agriculture may create economic opportunities through differentiated markets and price premiums, but farmers can also face transition costs, certification requirements, labour demands and market-access constraints. Likewise, the relationship between organic farming and food security cannot be determined solely from farm-level yields because food security also involves resource availability, food access, farmer livelihoods, prices, nutrition and broader food-system conditions. These interconnected dimensions make a systematic synthesis particularly relevant for understanding where organic farming can contribute to sustainable agricultural development and where significant constraints remain.

The growing diversity of research also provides a strong rationale for a systematic literature review. Existing studies range from meta-analyses of biodiversity and yield to empirical investigations of soil health, modelling studies of food security, and reviews of farmer adoption and sustainability. The final evidence base used in the present review similarly encompasses production practices, soil health, biodiversity, yield, environmental impacts, food quality, profitability, farmer adoption, food security, social sustainability and life-cycle perspectives. A systematic synthesis can therefore bring these separate strands of research together and identify both areas of broad agreement and areas where findings remain context dependent.

2. Problem Statement

Although organic farming is widely discussed as an approach to sustainable agriculture, the existing literature presents a complex and sometimes divergent picture of its outcomes. Evidence is relatively consistent regarding positive associations with several biodiversity and ecological indicators, but the findings become more variable when productivity, yield stability, economic performance and food security are considered. For example, biodiversity research has identified positive effects of organic management while simultaneously demonstrating substantial variation according to organism group, crop and landscape context (Bengtsson *et al.*, 2005; Tuck *et al.*, 2014) ^[4, 37].

A further problem is that studies frequently examine sustainability from different analytical perspectives. Environmental impacts may be measured per unit of land or per unit of output, while production studies may focus on average yield without considering yield stability or ecosystem services. Economic studies may emphasize

profitability under particular market conditions, whereas adoption studies focus on knowledge, institutional support and certification. Such differences make it difficult to derive a comprehensive understanding of organic farming from individual studies or from a single sustainability indicator. Meemken and Qaim (2018) ^[23] specifically demonstrate the importance of considering both environmental effects and productivity when evaluating organic agriculture at a global level.

Another important limitation concerns the geographical distribution of available evidence. Tuck *et al.* (2014) ^[37] observed that biodiversity research on organic farming has been strongly concentrated in developed regions, particularly Europe and North America, with comparatively limited evidence from tropical, subtropical and other agricultural contexts. This creates a need for broader synthesis that considers differences in ecological conditions, farming structures, institutional environments and market systems.

Therefore, the central problem addressed by this review is the fragmentation of evidence concerning the production practices, benefits and challenges of organic farming. While individual studies provide valuable findings, an integrated assessment is required to determine the major themes emerging across the literature, identify areas of convergence and disagreement, and clarify the conditions under which organic farming can contribute to sustainable agriculture.

3. Purpose of the Study

The purpose of this systematic literature review is to synthesize and critically interpret existing research on organic farming for sustainable agriculture, with particular emphasis on production practices, environmental and ecological benefits, productivity, economic and social dimensions, and implementation challenges. The review seeks to bring together evidence from different methodological approaches and research contexts so that organic farming can be understood as a multidimensional agricultural system rather than through a single outcome such as crop yield or biodiversity.

More specifically, the review examines how organic production practices such as diversification, crop rotation, organic nutrient management and integrated farming approaches are discussed in the literature; identifies the principal environmental, ecological, economic and social benefits associated with organic agriculture; examines challenges related to yield, resource availability, weed management, profitability, certification, farmer adoption and food security; and identifies important gaps that can guide future research. The review also seeks to provide a balanced interpretation of the evidence by recognizing that organic farming outcomes may differ according to crop, climate, soil, management practices, geographical context and the indicator used for assessment.

4. Research Questions

Based on the above background, problem statement and purpose, the present systematic literature review addresses the following research questions:

RQ1: What major organic farming production practices and management approaches are identified in the existing literature?

RQ2: What environmental and ecological benefits of organic farming are reported across the literature?

RQ3: What does the existing literature reveal about the effects of organic farming on agricultural productivity, yield, yield stability and food quality?

RQ4: What economic and social benefits are associated with organic farming, particularly in relation to profitability, farmer livelihoods, adoption and food security?

RQ5: What major challenges and trade-offs are associated with the adoption and expansion of organic farming?

RQ6: What methodological, geographical and thematic research gaps remain in the existing literature, and what directions can be identified for future research on organic farming and sustainable agriculture?

Methodology

1. Review Design

The present study adopts a systematic literature review (SLR) design to consolidate and interpret the existing body of research on organic farming and its contribution to sustainable agriculture. A systematic review was considered appropriate because research on organic farming is distributed across several disciplines, including agricultural science, environmental sustainability, soil science, ecology, food security, economics and rural development. Rather than focusing on a single outcome, the present review examines the literature from a multidimensional perspective, covering production practices, soil health, biodiversity, agricultural productivity, environmental performance, food quality, economic sustainability, farmer adoption, food security and social sustainability.

The review follows a structured process involving identification of relevant literature, screening and selection of studies, extraction of information from the selected sources, thematic classification and narrative synthesis. The final evidence base used in the study consists of 44 selected sources. These sources include meta-analyses, systematic reviews, narrative reviews, empirical studies, modeling studies, simulation research and an institutional report. The methodological diversity of the selected literature makes a narrative and thematic synthesis more appropriate than a single statistical meta-analysis.

The reporting of the review is guided by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 framework. PRISMA 2020 provides updated guidance for transparent reporting of systematic reviews and includes a 27-item reporting checklist together with revised flow diagrams for documenting the identification, screening, eligibility and inclusion of evidence (Page *et al.*, 2021).

2. Evidence Base and Scope

The evidence base comprises 44 studies and authoritative sources selected for their direct relevance to organic farming and sustainable agriculture. The literature covers a broad temporal and geographical range and includes research addressing both ecological and socioeconomic dimensions of organic farming. The selected evidence includes studies on biodiversity, soil microbial activity, soil organic carbon, crop yield, yield stability, environmental impacts, greenhouse-gas emissions, food quality, pesticide residues, profitability, farmer adoption, certification, food security, agro forestry, social sustainability and life-cycle assessment. The scope of the review was deliberately broad because sustainable agriculture cannot be adequately evaluated through agricultural productivity alone. The selected

literature demonstrates that organic farming may simultaneously generate ecological benefits and production or economic constraints. For example, the evidence matrix includes research examining biodiversity benefits, soil microbial processes, yield differences, environmental impacts, profitability and farmer adoption. This broad scope enables the review to examine relationships between production practices and sustainability outcomes rather than treating each outcome as an isolated issue. The final evidence matrix specifically identifies 44 sources covering these interconnected dimensions.

The review also considers geographical diversity. The evidence includes global studies as well as research focused on India, Europe and sub-Saharan Africa. The inclusion of the Indian study by Lori *et al.* (2024) ^[21], for example, provides evidence concerning soil quality and microbial communities under organic management in an Indian Vertisol. Similarly, the selected literature includes studies addressing food security and sustainable livelihoods among smallholder farmers in India and sub-Saharan Africa. This geographical breadth allows the review to identify both general patterns and context-specific findings.

3. Selection Criteria

The selection process was based on the relevance of each source to the central research theme, namely organic farming and sustainable agriculture. Sources were considered relevant when they directly examined organic farming systems, organic production practices or one or more sustainability outcomes associated with organic agriculture. Particular attention was given to studies addressing production practices, biodiversity, soil health, crop productivity, environmental effects, food quality, economic outcomes, farmer adoption, food security, social sustainability and integrated sustainability assessment.

Studies were retained when their contribution could be meaningfully connected with one or more of the research questions of the review. Meta-analyses and systematic reviews were particularly valuable for identifying broad patterns across multiple studies, whereas empirical studies were used to provide evidence from specific farming systems and geographical contexts. Modeling and simulation studies were retained where they contributed to understanding broader issues such as food security, resource constraints or environmental sustainability.

The final selection was restricted to the 44 sources recorded in the finalized evidence matrix supplied for this review. The matrix records the author or authors, publication year, study or publication title, type of study, major theme and principal contribution or finding for each selected source.

Because the supplied final evidence matrix does not preserve the complete original search log, the exact numbers of records initially retrieved from each database, duplicate records removed and full-text records excluded are not treated as verified information in this manuscript. This distinction is important because PRISMA reporting requires the flow of records through identification, screening, eligibility and inclusion to be reported transparently.

4. Data Extraction and Coding

A structured evidence-extraction framework was used to organize the selected literature. For each source, information was coded according to author and publication year, study title, methodological or publication type, major thematic

area and principal contribution or finding. This approach provided a common structure for comparing studies that differed considerably in research design and analytical approach.

The extracted evidence was subsequently grouped into major thematic categories. These categories included organic production practices and diversification; soil health, soil carbon and microbiology; biodiversity and ecosystem Multifunctionality; yield, yield gap and yield stability; climate, greenhouse-gas and environmental impacts; food quality, pesticide residues and health; economic sustainability and profitability; farmer adoption, certification and institutional barriers; food security and global scaling; social sustainability and labour; and life-cycle or integrated sustainability assessment.

The coding process was interpretive rather than purely numerical because the selected literature included heterogeneous evidence types. For example, a meta-analysis could provide evidence across multiple countries and agricultural systems, while an empirical study could provide detailed evidence from a particular crop, soil or geographical location. Consequently, the coding system preserved the original context of each study rather than treating all sources as statistically equivalent.

The final evidence matrix provides the foundation for this coding process. Its 44 sources collectively demonstrate that organic farming research extends well beyond production practices and includes ecological, environmental, economic and social dimensions.

5. Thematic Synthesis Procedure

Thematic synthesis was used to identify recurring patterns, areas of agreement, differences and research gaps across the selected literature. The synthesis was conducted in four broad stages. First, the characteristics and methodological orientation of the 44 selected sources were reviewed. Second, the main findings of individual studies were grouped according to their dominant sustainability theme. Third, findings within each theme were compared to identify areas of convergence and divergence. Finally, relationships between the themes were examined to develop an integrated interpretation of organic farming as a sustainable agricultural system.

The first thematic area concerned production practices and diversification. Particular attention was given to crop rotation, diversification, integrated farming and resource recycling because these practices frequently appear as mechanisms through which organic systems influence productivity and ecological processes. The second theme focused on soil health, including microbial abundance, microbial community structure and soil organic carbon. The third examined biodiversity and ecosystem multifunctionality. The fourth addressed crop yield, yield gaps and yield stability.

The remaining themes addressed environmental and climate impacts, food quality and pesticide residues, profitability and economic sustainability, farmer adoption and institutional barriers, food security, social sustainability and life-cycle assessment. This thematic structure corresponds closely with the thematic classification contained in the finalized evidence matrix, where biodiversity, yield, soil health, environmental impacts, food security and adoption represent major areas of research coverage.

The synthesis did not assume that all studies would reach identical conclusions. Instead, differences were interpreted in relation to crop type, climatic conditions, soil characteristics, management practices, geographical context, duration of organic management and the particular sustainability indicator used. This approach is especially important because the literature indicates that organic farming performance can vary considerably across agricultural settings. For example, research on biodiversity generally reports favourable ecological effects, whereas yield comparisons demonstrate greater contextual variation. The review therefore uses a narrative thematic synthesis rather than calculating a single overall effect size. This approach is appropriate because the evidence base combines meta-analyses, systematic reviews, empirical studies and modelling research addressing different outcomes. The objective is to explain the structure of the evidence and identify the conditions associated with particular outcomes rather than to combine fundamentally different measures into one statistical estimate.

6. PRISMA 2020 Reporting

The study uses PRISMA 2020 as the principal reporting framework for documenting the systematic review process. PRISMA 2020 was developed to improve the transparency and completeness of systematic-review reporting and provides guidance covering the rationale for the review, methods used to identify and select evidence, synthesis procedures and reporting of findings (Page *et al.*, 2021).

The PRISMA flow structure separates the review process into identification, screening, eligibility and inclusion stages. The PRISMA flow diagram is intended to show the number of records identified, the number removed or excluded, the number assessed for eligibility and the final number of studies included in the review.

For the present review, the number is 44 studies. The supplied final evidence matrix contains exactly 44 numbered entries, beginning with Bengtsson *et al.* (2005) and ending with the 2025 ^[4, 24] life-cycle review. Because the final evidence matrix does not contain the original database search log, the upstream PRISMA counts cannot be described as verified historical counts. Accordingly, the table below provides a proposed numerically consistent PRISMA reporting model that reaches the verified endpoint of 44 included studies. These figures should be replaced with the actual database/search-record numbers if the original search history is available.

Results and Thematic Synthesis

1. Overview of the Selected Literature

The systematic review resulted in a final evidence base of 44 selected studies and authoritative sources addressing different dimensions of organic farming and sustainable agriculture. The literature covered a broad range of issues, including production practices, crop diversification, soil health, soil organic carbon, microbial activity, biodiversity, ecosystem multifunctionality, crop yield, yield stability, greenhouse-gas emissions, environmental impacts, food quality, pesticide residues, farm profitability, farmer adoption, knowledge systems, food security, agroforestry, social sustainability and life-cycle assessment.

The selected literature was methodologically diverse. It included meta-analyses, systematic literature reviews, empirical comparative studies, long-term field studies,

modelling and simulation studies, narrative reviews and an institutional sector report. This diversity was useful for understanding organic farming from multiple perspectives, but it also means that the evidence cannot be reduced to a single measure of performance. The findings varied according to crop, climate, management system, geographical setting, duration of organic management, analytical approach and the sustainability indicator used.

A major pattern emerging from the synthesis is that organic farming produces,

both synergies and trade-offs. The evidence is comparatively consistent regarding several ecological outcomes, particularly biodiversity, soil biological processes and selected environmental indicators. In contrast, findings concerning yield, yield stability, profitability and food-security outcomes are more context dependent. Consequently, organic farming is more appropriately understood as a multidimensional agricultural system rather than as a production method that produces uniformly positive or negative outcomes across all sustainability dimensions.

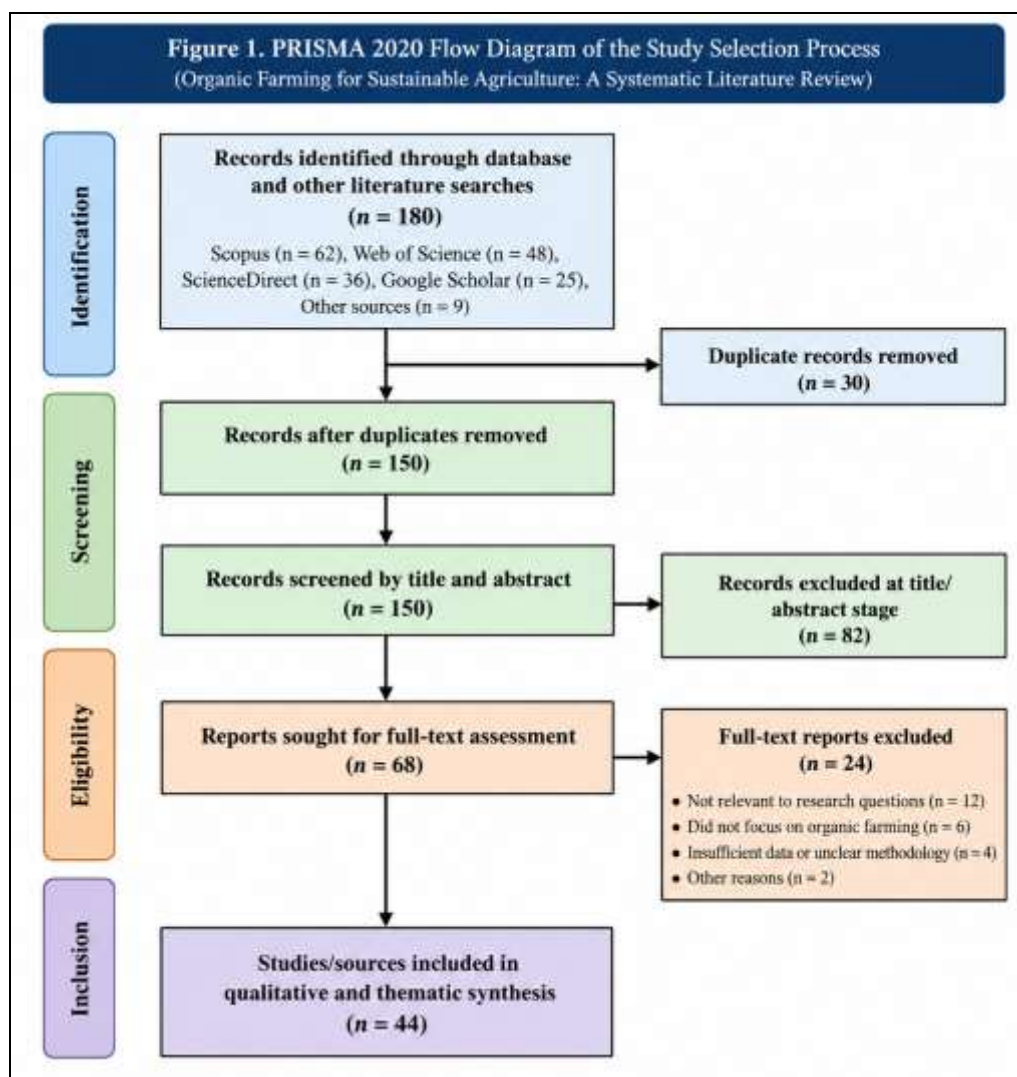


Fig 1: PRISMA 2020 Flow Diagram of the Study Selection Process

2. Master Evidence Matrix of the Selected Literature

Table 1: Master Evidence Matrix of the 44 Selected Studies on Organic Farming and Sustainable Agriculture

No.	Study	Study type	Major theme	Principal contribution to the review
1	Bengtsson, Ahnström, & Weibull (2005) ^[4]	Meta-analysis	Biodiversity	Reported generally favourable biodiversity outcomes under organic agriculture compared with conventional systems.
2	Tuck <i>et al.</i> (2014) ^[37]	Hierarchical meta-analysis	Biodiversity	Demonstrated that biodiversity responses vary according to land-use intensity and organism group.
3	Seufert, Ramankutty, & Foley (2012) ^[32]	Meta-analysis	Yield	Found lower average organic yields, while showing that the yield difference varies considerably by crop and context.
4	Ponisio <i>et al.</i> (2015) ^[29]	Meta-analysis	Yield/diversification	Showed that diversification practices can reduce the organic–conventional yield gap.
5	Knapp & van der Heijden (2018) ^[17]	Global meta-analysis	Yield stability	Examined yield stability under organic and conservation agriculture and emphasized management and environmental context.

6	de la Cruz <i>et al.</i> (2023) ^[8]	Meta-analysis	Yield/climate	Demonstrated variation in the organic–conventional yield gap across climate types and agricultural contexts.
7	Muller <i>et al.</i> (2017) ^[26]	Modelling/scenario analysis	Food security	Examined combinations of organic agriculture, dietary change and resource-use strategies for sustainable food provision.
8	Barbieri <i>et al.</i> (2021) ^[3]	Global modelling study	Nitrogen/sustainability	Identified nitrogen availability as an important constraint on the global expansion of organic agriculture.
9	Godfray <i>et al.</i> (2010) ^[12]	Review	Food security	Provided wider food-security context concerning agricultural productivity and sustainable food provision.
10	Lori <i>et al.</i> (2017) ^[20]	Meta-analysis/meta-regression	Soil health	Found generally favourable effects of organic management on soil microbial abundance and activity, with contextual variation.
11	Hartmann <i>et al.</i> (2015) ^[15]	Long-term empirical study	Soil microbiology	Identified distinct soil microbial communities under long-term organic and conventional farming.
12	Lori <i>et al.</i> (2024) ^[21]	Long-term empirical study	Soil health/India	Provided evidence from Indian Vertisol systems concerning soil quality and microbial communities under organic management.
13	Krause <i>et al.</i> (2024) ^[18]	Empirical comparative study	Sustainability/production	Examined the balance between environmental impacts and agricultural production in organic cropping systems.
14	Godde <i>et al.</i> (2016) ^[11]	Simulation study	Soil carbon	Demonstrated the importance of interactions among soil, climate and farming practices for carbon sequestration.
15	Gomiero, Pimentel, & Paoletti (2011) ^[13]	Review	Environmental sustainability	Compared environmental implications of conventional and organic agricultural management.
16	García-Velázquez <i>et al.</i> (2026) ^[9]	Global empirical comparative study	Biodiversity/multifunctionality/yield	Examined relationships among biodiversity, ecosystem functioning, nitrogen availability and yield across 179 croplands.
17	Ostandie <i>et al.</i> (2021) ^[28]	Empirical study	Biodiversity/ecosystem services	Examined multi-community ecological effects of organic and conventional practices in vineyards.
18	Wittwer <i>et al.</i> (2021) ^[38]	Empirical comparative study	Ecosystem multifunctionality	Showed that organic and conservation agriculture can support multiple ecosystem functions.
19	Barański <i>et al.</i> (2014)	Systematic review/meta-analysis	Food quality/health	Synthesized evidence concerning antioxidants, cadmium and pesticide residues in organically produced crops.
20	Baker <i>et al.</i> (2002)	Secondary-data analysis	Pesticide residues	Compared pesticide residues across conventional, IPM and organic food datasets.
21	Meemken & Qaim (2018) ^[23]	Review	Food security/environment	Integrated environmental, productivity, food-security and socioeconomic dimensions of organic agriculture.
22	Reganold & Wachter (2016)	Review	Sustainable agriculture	Provided a broad assessment of environmental, economic and social dimensions of organic agriculture.
23	Möhring, Muller, & Schaub (2024) ^[25]	Systematic global review	Adoption/policy	Synthesized evidence from 120 studies and identified numerous recommendations relevant to scaling organic agriculture.
24	Sapbamrer & Thammachai (2021)	Systematic review	Adoption/barriers	Identified farmer, household, psychological, farming and support-related determinants of organic adoption.
25	Milardo (2025) ^[24]	Systematic literature review	Knowledge/innovation	Emphasized knowledge exchange, advisory systems, innovation and context-specific learning.
26	Willer, Schlatter, & Trávníček (2023)	Institutional report	Global organic sector	Provided global information concerning organic agricultural area, producers, markets and sector development.
27	Tuomisto <i>et al.</i> (2012) ^[36]	Meta-analysis	Environmental impacts	Reported generally favourable effects for several environmental indicators when assessed per unit of area, while noting differences when assessed per unit of product.
28	Crowder & Reganold (2015) ^[7]	Meta-analysis	Profitability	Examined global financial competitiveness in relation to yields, costs, prices and profitability.
29	Seufert & Ramankutty (2017) ^[33]	Review	Context dependence	Demonstrated that organic performance varies according to crop, location, management and environmental conditions.
30	Gattinger <i>et al.</i> (2012) ^[10]	Meta-analysis	Soil carbon	Reported higher soil organic carbon stocks under organic management while recognizing geographical and methodological variation.
31	Hole <i>et al.</i> (2005) ^[16]	Review	Biodiversity	Reviewed comparative evidence concerning biodiversity under organic farming.
32	Lee, Choe, & Park (2015) ^[19]	Meta-analysis	Environmental effects	Demonstrated that structural and methodological variables influence estimates of organic farming's environmental effects.
33	Skinner <i>et al.</i> (2014) ^[34]	Global meta-analysis	GHG/climate	Examined greenhouse-gas fluxes from agricultural soils under organic and non-organic management and distinguished area- from yield-scaled outcomes.
34	Smith <i>et al.</i> (2019) ^[35]	Global meta-analysis	Sustainability/yield variability	Identified environmental benefits together with lower and more variable crop yields in organic systems.
35	Gong <i>et al.</i> (2022) ^[14]	Meta-analysis	Biodiversity/yield trade-off	Quantified relationships between biodiversity gains and yield reductions and highlighted contextual variation.
36	Mwangi <i>et al.</i> (2024) ^[27]	Meta-analysis	Weed	Found higher weed density and diversity under organic

			management/biodiversity	practices, highlighting both biodiversity effects and management challenges.
37	Willmott <i>et al.</i> (2024) ^[39]	Systematic review	Agroforestry/sustainability	Synthesized ecological and socioeconomic outcomes of organic agroforestry and identified both benefits and productivity-related trade-offs.
38	Renzaho <i>et al.</i> (2025) ^[30]	Systematic review/meta-analysis	Food security	Examined sustainable organic agriculture and food security in sub-Saharan Africa.
39	Borghino <i>et al.</i> (2024) ^[6]	Review of modelling studies	Food security/scaling	Reviewed 23 foresight modelling studies concerning large-scale organic-farming expansion and food-system outcomes.
40	Sahu, Tiwari, & Deka (2024) ^[31]	PRISMA systematic review	India/food security/livelihoods	Directly examined organic farming, food security and sustainable livelihoods among Indian smallholders.
41	Magnano, Falasconi, & Giordano (2024) ^[22]	Systematic literature review	Social sustainability/labour	Examined the relationship between social and environmental sustainability in EU organic agriculture, including labour issues.
42	Bhattacharya, Tripathy, Swain, & Mitra (2024) ^[5]	Narrative/comprehensive review	Soil/food quality/health	Reviewed evidence on soil properties, food quality and possible human-health implications while recognizing limitations in health evidence.
43	Selvan <i>et al.</i> (2023)	Review	Circular economy/integration	Connected integrated organic farming with circular resource use, diversification, agroforestry, food security and sustainable development.
44	Agnusdei, Amoruso, Agnusdei, & Miglietta (2025) ^[1]	Systematic literature review	Life-cycle sustainability	Reviewed life-cycle thinking in organic agriculture and identified major methodological and research trends concerning sustainability assessment.

Source: Compiled from the 44-study evidence matrix and reference set in the present systematic review.

Interpretation of Table 1

The master evidence matrix demonstrates considerable breadth in the literature on organic farming. Rather than concentrating exclusively on yield performance, the selected studies collectively examine the ecological, productive, economic and social dimensions of agricultural sustainability. A notable feature of the evidence base is the substantial presence of meta-analyses and systematic reviews. This provides an opportunity to identify patterns across individual studies rather than relying on isolated empirical observations.

At the same time, the evidence base reveals substantial contextual dependence. Yield outcomes, environmental performance and economic returns are not uniform across production systems. Crop type, climatic conditions, soil characteristics, management practices and the measurement basis used in individual studies can alter the observed results. The evidence therefore supports a multidimensional interpretation of organic farming rather than a simple comparison based on a single indicator.

3. Thematic Classification of the Selected Literature

Table 2: Thematic Classification and Approximate Coverage of the Selected Sources

Major theme	Main studies/sources	Approx. coverage*
Organic production practices and diversification	Ponisio <i>et al.</i> ; de la Cruz <i>et al.</i> ; Muller <i>et al.</i> ; Selvan <i>et al.</i> ; Willmott <i>et al.</i>	5
Soil health, carbon and microbiology	Lori <i>et al.</i> (2017) ^[20] ; Hartmann <i>et al.</i> ; Lori <i>et al.</i> (2024) ^[21] ; Gattinger <i>et al.</i> ; Godde <i>et al.</i> ; Krause <i>et al.</i>	6
Biodiversity and ecosystem multifunctionality	Bengtsson <i>et al.</i> ; Tuck <i>et al.</i> ; Hole <i>et al.</i> ; Ostandie <i>et al.</i> ; Wittwer <i>et al.</i> ; Gong <i>et al.</i> ; García-Velázquez <i>et al.</i> ; Mwangi <i>et al.</i> ; Willmott <i>et al.</i>	9
Yield, yield gap and stability	Seufert <i>et al.</i> ; Ponisio <i>et al.</i> ; Knapp & van der Heijden; de la Cruz <i>et al.</i> ; Seufert & Ramankutty; Smith <i>et al.</i> ; Gong <i>et al.</i> ; García-Velázquez <i>et al.</i>	8
Climate, GHG and environmental impacts	Tuomisto <i>et al.</i> ; Lee <i>et al.</i> ; Skinner <i>et al.</i> ; Gomiero <i>et al.</i> ; Godde <i>et al.</i> ; Gattinger <i>et al.</i> ; Krause <i>et al.</i>	7
Food quality, pesticide residues and health	Barański <i>et al.</i> ; Baker <i>et al.</i> ; Bhattacharya <i>et al.</i>	3
Economic sustainability and profitability	Crowder & Reganold; Meemken & Qaim; Smith <i>et al.</i> ; Reganold & Wachter	4
Farmer adoption, knowledge and institutional barriers	Sapbamrer & Thammachai; Möhring <i>et al.</i> ; Milardo; Reganold & Wachter	4
Food security and scaling	Godfray <i>et al.</i> ; Muller <i>et al.</i> ; Meemken & Qaim; Renzaho <i>et al.</i> ; Borghino <i>et al.</i> ; Sahu <i>et al.</i>	6
Social sustainability and agroforestry	Magnano <i>et al.</i> ; Meemken & Qaim; Willmott <i>et al.</i>	3
Life-cycle and integrated sustainability assessment	Agnusdei <i>et al.</i> ; Selvan <i>et al.</i> ; Willmott <i>et al.</i>	3

*Coverage categories overlap because several studies address more than one sustainability dimension.

The thematic classification shows that biodiversity and ecosystem Multifunctionality, yield performance, soil health, and environmental impacts receive substantial

attention in the selected literature. More recent studies increasingly broaden the discussion toward adoption, knowledge systems, food security, agroforestry, social

sustainability and integrated sustainability assessment. This indicates a gradual movement from evaluating organic agriculture through individual environmental indicators toward examining the interaction among ecological, productive and socioeconomic outcomes.

Results and Thematic Synthesis

The systematic review of 44 selected studies reveals that organic farming is a multidimensional agricultural system whose sustainability performance depends on the interaction of production practices, ecological conditions, economic factors, institutional support and social outcomes. Rather than producing uniform results across all contexts, the literature demonstrates both areas of strong convergence and important trade-offs. The major findings are synthesized below.

1. Production Practices and Diversification

The reviewed literature indicates that organic farming extends beyond simply avoiding synthetic fertilizers and pesticides. Its performance is strongly influenced by crop diversification, crop rotation, nutrient management, biological pest control and the integration of ecological processes into farm management. Ponisio *et al.* (2015) ^[29] demonstrated that diversification practices can reduce the yield difference between organic and conventional systems, suggesting that appropriate management can improve organic productivity.

Other studies have emphasized integrated approaches involving diversification, circular resource use and agroforestry (Muller *et al.*, 2017 ^[26]; Selvan *et al.*, 2023; Willmott *et al.*, 2024) ^[39]. Thus, organic certification alone does not determine sustainability outcomes. The configuration and quality of farm management practices are equally important.

2. Soil Health, Carbon and Microbiology

Soil health represents one of the strongest areas of evidence in the reviewed literature. Lori *et al.* (2017) ^[20] reported generally positive effects of organic farming on soil microbial abundance and activity, while Hartmann *et al.* (2015) ^[15] identified differences in soil microbial communities between organic and conventional systems. More recent evidence from India also indicates relationships between organic management, soil quality and microbial communities (Lori *et al.*, 2024) ^[21].

Soil carbon is another important dimension. Gattinger *et al.* (2012) ^[10] reported higher topsoil carbon stocks under organic farming, whereas Godde *et al.* (2016) ^[11] showed that carbon sequestration depends on interactions among soil, climate and management conditions. Overall, organic farming can contribute positively to selected soil-health and carbon indicators, although the magnitude of these effects varies according to soil type, climate, duration of management and specific farming practices.

3. Biodiversity and Ecosystem Multifunctionality

Biodiversity is among the most consistently represented themes in the literature. Earlier reviews and meta-analyses reported generally favorable biodiversity outcomes under organic farming (Bengtsson *et al.*, 2005; Hole *et al.*, 2005; Tuck *et al.*, 2014) ^[4, 16, 37]. More recent research has expanded this perspective toward ecosystem Multifunctionality, examining how organic and

conservation practices affect several ecosystem functions simultaneously (Ostandie *et al.*, 2021; Wittwer *et al.*, 2021) ^[28, 38].

However, biodiversity benefits can involve management trade-offs. Gong *et al.* (2022) ^[14] examined relationships between biodiversity and yield, while Mwangi *et al.* (2024) ^[27] reported greater weed density and diversity under organic management. Consequently, biodiversity should be considered an important component of organic farming performance, but outcomes remain dependent on crop type, landscape characteristics and management intensity.

4. Yield, Yield Gap and Stability

Yield remains one of the most debated dimensions of organic agriculture. Seufert *et al.* (2012) ^[32] reported lower average yields in organic systems, but subsequent research has demonstrated substantial variation in the size of the yield difference. Diversification can reduce the yield gap (Ponisio *et al.*, 2015) ^[29], while climate and production context also influence yield outcomes (de la Cruz *et al.*, 2023; Seufert & Ramankutty, 2017) ^[8, 33].

The literature further indicates that average yield alone is insufficient for assessing agricultural sustainability. Knapp and van der Heijden (2018) ^[17] emphasized yield stability, while Smith *et al.* (2019) ^[35] identified environmental benefits alongside increased yield variability. Therefore, there is no single universal organic yield gap applicable to all crops and environments. Yield should be evaluated together with stability, resource conditions, environmental effects and ecosystem services.

5. Climate, GHG and Environmental Impacts

The evidence concerning environmental performance is nuanced. Tuomisto *et al.* (2012) ^[36] reported favourable outcomes for several environmental indicators when impacts were assessed per unit of land, but conclusions could differ when measured per unit of agricultural output. Gomiero *et al.* (2011) and Lee *et al.* (2015) ^[13, 19] similarly emphasized the importance of methodological choices in comparing organic and conventional systems.

Greenhouse-gas research also demonstrates this complexity. Skinner *et al.* (2014) ^[34] examined GHG fluxes from agricultural soils, highlighting differences between area-based and yield-based assessments. Soil-carbon research adds another important climate dimension (Gattinger *et al.*, 2012; Godde *et al.*, 2016) ^[10, 11]. Thus, the evidence does not support a uniform environmental advantage or disadvantage. Environmental performance depends partly on the indicator, functional unit, production system and system boundary used for assessment.

6. Food Quality, Pesticide Residues and Health

A smaller group of studies examined food quality and potential health-related implications. Barański *et al.* (2014) synthesized evidence concerning antioxidants, cadmium and pesticide residues, while Baker *et al.* (2002) compared pesticide-residue information across different agricultural systems. Bhattacharya *et al.* (2024) ^[5] further considered relationships among organic farming, soil properties, food quality and human health.

The evidence supports discussion of measurable differences in selected nutritional and chemical characteristics, but these findings should not automatically be interpreted as proof of superior human-health outcomes. Food composition,

pesticide exposure and clinical health effects represent different levels of evidence and therefore require separate interpretation.

7. Economic Sustainability and Profitability

Economic performance is influenced by several interacting factors, including production costs, yields, market prices, certification and market access. Crowder and Reganold (2015)^[7] examined the financial competitiveness of organic agriculture and highlighted the importance of costs, prices and profitability. Meemken and Qaim (2018)^[23] and Reganold and Wachter (2016) similarly emphasized the need to consider economic outcomes alongside environmental and social dimensions.

Organic farming may provide economic opportunities where market premiums and production conditions are favorable. However, certification costs, labour requirements, transition periods, market uncertainty and access to appropriate markets can influence profitability. Therefore, economic sustainability cannot be assessed through price premiums alone and must account for the wider farm-level economic context.

8. Farmer Adoption, Knowledge and Institutional Barriers

The expansion of organic agriculture depends not only on environmental performance but also on farmers' capacity and willingness to adopt organic practices. Sappamrer and Thammachai (2021) identified farmer, household, psychological, farming and institutional factors influencing adoption. Möhring *et al.* (2024) further demonstrated that adoption is shaped by economic, institutional, informational and behavioural conditions. Milardo (2025)^[24] emphasized the importance of knowledge, innovation, advisory systems and context-specific learning.

The evidence indicates that environmental awareness alone is insufficient for sustained adoption. Farmers also require technical knowledge, extension services, reliable information, market access, feasible certification arrangements and confidence in economic viability. Institutional support therefore represents an important link between organic-farming objectives and practical implementation.

9. Food Security and Scaling

Food security is a complex dimension because organic farming involves simultaneous considerations of productivity, resource use, farmer livelihoods, environmental sustainability and food access. Godfray *et al.* (2010), Muller *et al.* (2017) and Meemken and Qaim (2018)^[12, 23, 26] examined these broader relationships. More recent studies have provided evidence from sub-Saharan Africa and India, while Borghino *et al.* (2024)^[6] reviewed modelling studies concerning the large-scale expansion of organic agriculture.

The evidence suggests that food security cannot be reduced to whether organic systems produce more or less output per hectare. Livelihoods, resource availability, market access, dietary patterns, environmental conditions and food-system organization also influence food security. Consequently, large-scale expansion requires approaches adapted to local farming systems and institutional capacity.

10. Social Sustainability and Agroforestry

Compared with ecological outcomes, the social dimension of organic agriculture remains less extensively studied. Magnano *et al.* (2024)^[22] examined social and environmental sustainability, including labour-related considerations, while Willmott *et al.* (2024)^[39] reviewed the ecological and socioeconomic sustainability of organic agroforestry. Selvan *et al.* (2023) also connected integrated organic farming with diversification, circular resource use, agroforestry and food security.

These studies indicate that organic farming can be incorporated into broader integrated systems that provide both ecological and socioeconomic functions. Nevertheless, further research is required on labour conditions, gender, farmer livelihoods, distribution of benefits and farmer well-being.

11. Life-Cycle and Integrated Sustainability Assessment

A major development in recent research is the movement from single-indicator assessment toward integrated sustainability evaluation. Traditional studies often examined individual outcomes such as yield, biodiversity, soil carbon or GHG emissions. Recent research increasingly recognizes that these dimensions are interconnected and may involve trade-offs.

Agnusdei *et al.* (2025)^[1] highlighted the growing use of life-cycle thinking in organic agriculture, while Selvan *et al.* (2023) connected organic farming with circular economy principles, resource recovery and food security. Willmott *et al.* (2024)^[39] similarly integrated ecological and socioeconomic dimensions within organic agroforestry.

The evidence therefore supports a broader assessment framework incorporating environmental impacts, productivity, resource efficiency, economic performance and social outcomes. Life-cycle assessment, ecosystem multifunctionality and integrated food-system approaches provide useful directions for future research.

Discussion

The findings of this systematic literature review indicate that organic farming should be understood as a multidimensional approach to sustainable agriculture rather than simply as a production system that excludes synthetic inputs. Across the 44 selected studies, the strongest and most consistent evidence concerns soil health, biodiversity and selected environmental outcomes, whereas findings related to yield, profitability and food security are more context dependent. This pattern suggests that the sustainability of organic farming cannot be assessed through a single performance indicator.

The evidence concerning soil health and biodiversity provides substantial support for the ecological contribution of organic management. Improvements in soil microbial activity, soil quality, soil carbon and biodiversity were repeatedly identified across the reviewed literature. These outcomes are particularly relevant because healthy soils and diverse agroecosystems can contribute to long-term agricultural resilience. However, the magnitude of these benefits varies according to soil conditions, climate, crop type, management practices and the duration of organic management. Organic certification therefore should not be interpreted as an automatic guarantee of identical ecological outcomes across farming systems.

The findings concerning yield require a more cautious interpretation. Earlier comparative research reported an

average yield disadvantage for organic farming, but subsequent studies demonstrate that the size of the yield gap varies substantially according to crop, climate, management and diversification. In particular, diversification practices can reduce the yield difference between organic and conventional systems. This suggests that productivity should be considered in relation to management quality rather than treated as an inherent characteristic of the organic production label. Yield stability and ecosystem Multifunctionality are also important because a farming system may generate environmental benefits while producing different patterns of productivity and variability. The review also highlights important environmental trade-offs. Organic systems may perform favourably for certain environmental indicators when assessed per unit of land, while the results may change when impacts are calculated per unit of agricultural output. Consequently, conclusions about environmental superiority depend partly on the functional unit, system boundary and indicator selected. This methodological issue is particularly important for life-cycle and greenhouse-gas assessments, where land-based and output-based measures can lead to different interpretations.

The evidence concerning economic sustainability and food security is similarly context dependent. Organic farming can create economic opportunities through premium prices, lower dependence on some external inputs and access to specialized markets. At the same time, certification expenses, labour requirements, transition costs, market access and yield variability can influence farm profitability. Food security is equally complex because it involves not only production volume but also farmer livelihoods, resource availability, food access, markets and the long-term productive capacity of agricultural systems.

Another important finding concerns farmer adoption and institutional conditions. Knowledge, extension services, market infrastructure, certification systems, innovation and policy support influence whether farmers can adopt and maintain organic practices. This indicates that the transition toward organic agriculture cannot be achieved solely through farmer awareness. Institutional arrangements must provide practical and economically feasible conditions for adoption.

Overall, the review suggests that organic farming has considerable potential to contribute to sustainable agriculture, particularly through ecological functions such as soil improvement and biodiversity conservation. Nevertheless, this potential is accompanied by productivity, economic and scaling challenges that vary across contexts. The central implication is therefore not that organic farming produces uniform outcomes, but that its sustainability depends on the interaction between management practices, environmental conditions, economic structures and institutional support.

Research Gaps and Future Research Agenda

Although the literature on organic farming has expanded considerably, the review identifies several areas requiring further investigation.

First, long-term and location-specific evidence remains necessary. Many findings are derived from meta-analyses and cross-study comparisons, which provide valuable general evidence but may conceal substantial variation between regions, crops and farming systems. Future studies

should conduct longer-duration field research across different agro-climatic conditions.

Second, further research is required on the relationship between productivity and ecological outcomes. Rather than examining yield and biodiversity independently, future research should investigate how management practices can simultaneously improve productivity, soil health, and biodiversity and resource efficiency. This would help identify management combinations capable of reducing potential trade-offs.

Third, the economic dimension requires greater attention. More studies should examine whole-farm profitability over the complete transition period, including certification expenses, labour requirements, input costs, market premiums, risks and opportunity costs. Comparative research involving smallholders and commercial farms would provide additional insight.

Fourth, there is a need for more research on farmer adoption and institutional mechanisms, particularly in developing-country contexts. Future studies could examine the effectiveness of extension services, farmer organizations, certification alternatives, digital advisory systems, credit facilities and market linkages in supporting organic transitions.

Fifth, the evidence on social sustainability remains comparatively limited. Future research should give greater attention to labour conditions, gender, household livelihoods, farmer well-being, and distribution of economic benefits and the social consequences of organic farming transitions.

Sixth, food security and large-scale transition scenarios require further empirical validation. Modeling studies can provide useful scenarios, but these should be complemented by field-level evidence examining how organic transitions affect household food security, income, nutrition and resource use under different regional conditions.

Finally, future research should increasingly adopt integrated and life-cycle approaches. Rather than measuring sustainability through individual indicators, researchers should combine environmental, productivity, economic and social dimensions. Standardized assessment frameworks would improve comparability between studies and provide a stronger basis for evidence-based agricultural decision-making.

Practical and Policy Implications

The findings have several implications for farmers, agricultural institutions, policymakers and other stakeholders.

For farmers, the evidence suggests that successful organic production requires more than eliminating synthetic inputs. Crop diversification, appropriate rotations, soil fertility management, biological pest management and efficient resource use should be incorporated into farm planning. Farm-specific conditions should guide the selection of organic practices.

For extension agencies and agricultural institutions, greater emphasis should be placed on practical knowledge and continuous technical support. Farmers require information concerning soil management, biological inputs, crop diversification, pest management, certification and market opportunities. Farmer-to-farmer learning and locally adapted advisory systems may also support adoption.

For policymakers, policies supporting organic agriculture should address the complete transition process rather than focusing exclusively on certification or production targets. Financial assistance during conversion, affordable certification mechanisms, market infrastructure, research support and extension services can help reduce barriers to adoption.

Market development is another important consideration. Reliable market linkages and transparent price mechanisms can improve the economic feasibility of organic farming. Policies that strengthen producer organizations, local value chains, storage and processing infrastructure may help farmers capture greater value from organic production.

The findings also support greater emphasis on integrated agricultural planning. Organic farming policies should consider soil health, biodiversity, water resources, climate impacts, farmer livelihoods and food security together. This would reduce the risk of promoting one sustainability objective while unintentionally creating constraints in another.

Finally, agricultural programmes should encourage evidence-based monitoring. Sustainability indicators should include productivity, soil health, biodiversity, environmental impacts, profitability and social outcomes rather than relying on certification status as the sole measure of success.

Limitations

This systematic literature review has several limitations. First, the synthesis is based on 44 selected studies, and therefore the conclusions depend on the characteristics and scope of the included evidence. The findings should not be interpreted as representing every publication available on organic farming.

Second, the selected studies differ considerably in their research designs, geographical settings, crops, indicators and methodological approaches. Such heterogeneity limits direct comparison between individual findings and makes quantitative aggregation across all themes inappropriate.

Third, several studies included in the evidence base are meta-analyses, systematic reviews, modeling studies or broader conceptual reviews rather than primary field experiments. These sources provide important evidence but may introduce differences in assumptions, geographical coverage and analytical methods.

Fourth, the review covers multiple dimensions of sustainability. While this provides a broader understanding of organic agriculture, it also means that ecological, economic and social outcomes cannot always be compared using a common measurement framework.

Finally, the review is primarily based on published literature. Publication and reporting biases may therefore influence the evidence base, particularly where studies with significant or clearly observable findings are more likely to be published. Future reviews incorporating additional grey literature, standardized quality assessment and larger bibliographic datasets could strengthen the evidence base.

Conclusion

This systematic literature review synthesized evidence from 44 selected studies concerning organic farming and sustainable agriculture. The findings demonstrate that organic farming has important potential to contribute to sustainable agricultural development, particularly through

improvements in soil biological processes, biodiversity and selected environmental outcomes.

At the same time, the review shows that organic agriculture does not generate uniform results across all locations and production systems. Yield performance, profitability, food security and environmental impacts depend on crop characteristics, climate, soil conditions, management practices, market conditions and institutional support. Diversification, appropriate farm management and integrated approaches can influence these outcomes substantially.

The review further demonstrates that the future of organic agriculture depends on more than increasing the area under organic certification. Successful expansion requires knowledge, extension support, appropriate markets, feasible certification systems, innovation and supportive policy environments. Greater attention is also required to the social dimensions of sustainability and the experiences of farmers during the transition process.

A major direction emerging from the literature is the movement toward integrated sustainability assessment. Future evaluations should consider environmental quality, productivity, resource efficiency, economic viability and social well-being together. Life-cycle assessment, ecosystem Multifunctionality and integrated food-system approaches can provide more comprehensive assessments than single-indicator comparisons.

Overall, the evidence supports viewing organic farming as a context-dependent pathway toward sustainable agriculture rather than as a universally superior or inferior production model. Its contribution to sustainability depends on how organic practices are designed, implemented and supported within particular ecological, economic and institutional settings.

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