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The Economics of Sustainability in Organic Vegetable Systems: A Systematic Review

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ABSTRACT

Organic vegetable production in the United States employs a variety of sustainable farming practices, including diverse tillage methods, crop rotation systems, and mulching techniques, aimed at enhancing ecological balance. While the environmental benefits of these practices are widely acknowledged, their economic impacts vary considerably across different regions and farming systems. Understanding these economic variations is crucial for promoting the adoption of sustainable practices and ensuring the viability of organic vegetable farming. This study systematically evaluates the economic impacts of primary sustainable farming practices in organic vegetable crop production in the United States over the past decade. The primary objectives are to: Identify key sustainable farming practices used in organic vegetable production. Analyze the economic outcomes of these practices, including net returns, production costs, and labor requirements. Determine how economic impacts vary across different regions and production systems. A synthesis of data was conducted using information extracted from studies focused on organic vegetable production in the U.S. Studies were categorized based on: Study design. Geographic setting. Farm characteristics. Specific sustainable farming practices. Intervention details. Economic outcomes. Labor requirements. Soil health indicators. Comparative and thematic analyses were used to identify trends and variations in the economic impacts of different sustainable practices. The economic impacts of sustainable farming practices vary significantly. Tillage practices: Conservation tillage showed positive economic outcomes, while no-till systems presented challenges related to higher labor costs. Cover cropping: Results were mixed, with challenges observed in high tunnel systems., Regional variations: Economic outcomes were influenced by factors such as location and production system. Labor management: Efficient labor management was identified as a critical factor affecting economic viability. the economic sustainability of organic vegetable production is influenced by a complex interplay of farming practices, regional factors, and management strategies. While sustainable practices offer environmental benefits, their economic viability requires careful consideration of factors such as labor costs, input expenses, and regional market dynamics. Innovations that enhance efficiency and profitability are crucial for the continued growth and sustainability of organic vegetable farming.

Keywords: *Organic vegetable production, Sustainable farming practices, Economic sustainability, Conservation tillage, Cover cropping, Labor management, Production costs, Net returns, Systematic Review.*

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INTRODUCTION

In an era marked by increasing environmental consciousness and concerns over conventional agricultural practices, organic vegetable farming has garnered significant attention for its potential to foster ecological sustainability(Inveninato Carmona et al., 2021; Wekeza et al., 2022). Unlike conventional systems that often rely on synthetic inputs, organic agriculture emphasizes ecological balance through practices such as crop rotation, cover cropping, and biological pest control(Bergman & Pandhi, 2023). Understanding the multifaceted impacts of these sustainable farming practices is crucial for informing both agricultural policy and on-farm decision-making. While the environmental benefits of organic agriculture have been extensively studied, a comprehensive understanding of their economic implications, particularly within the context of vegetable production in the United States over the past decade, remains vital.

Organic vegetable production in the U.S. presents a diverse landscape of farming systems, with growers adopting a range of sustainable practices tailored to their specific regional and environmental conditions(Ali & Dahlhaus, 2022). These practices, including varied tillage methods, diverse crop rotation systems, and the integration of cover crops and mulching techniques, are implemented with the aim of enhancing soil health, conserving water resources, and promoting biodiversity(Preite et al., 2023). However, the economic outcomes associated with these practices can vary considerably, influenced by factors such as regional market dynamics, labor costs, input expenses, and yield performance (Jayasinghe et al., 2023).

This study aims to systematically evaluate the economic impacts of primary sustainable farming practices employed in organic vegetable crop production in the United States over the past decade. By synthesizing findings from existing research, this study seeks to identify key trends in the economic performance of various sustainable practices, considering factors such as net returns, production costs, and labor efficiency across different regions and production systems. Understanding the economic viability of these practices is essential for promoting their wider adoption and ensuring the long-term sustainability of organic vegetable farming in the U.S.

METHODS

This study employs a systematic review methodology to evaluate the economic impacts of sustainable farming practices within organic vegetable production systems in the United States. The review systematically identified, screened, and analyzed empirical studies published in the last decade that examined the relationship between various sustainable practices and economic outcomes in organic vegetable farming.

Using the Semantic Scholar corpus, a comprehensive search was conducted across 126 million academic papers to extract the 499 most relevant studies. From these, studies were selected based on predefined inclusion criteria focusing on crop type, sustainability focus, economic data availability, geographic relevance (U.S.-based), and empirical field conditions. The study design of each included paper was categorized (e.g., field trial, observational, comparative analysis) to ensure methodological rigor.

The data extraction process involved recording economic indicators (e.g., net returns per acre, labor inputs), agronomic practices (e.g., mulching, cover cropping, reduced tillage), geographic and farm characteristics, and soil health metrics. A mixed-method synthesis was conducted to compare outcomes across diverse practice types and regions, highlighting both successful strategies and economic trade-offs.

The review adheres to best practices in evidence synthesis, with a transparent selection protocol, relevance-focused screening, and structured data analysis using thematic coding. The findings contribute to the broader literature on organic farming economics and offer practical insights for policy-makers, agricultural advisors, and farm operators.

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Study Design

Table 1. *Description of PICO*

Component	Description
P-Population/Participants	U.S.-based organic vegetable farms (including small-scale, commercial, high tunnel, and field production systems).
I – Intervention	Implementation of sustainable agricultural practices such as crop rotation, mulching (straw, compost), no-till/reduced tillage, cover cropping, conservation tillage, and high-intensity cropping systems
C – Comparison	Conventional practices, or alternative organic practices (e.g., no-till vs. conventional tillage, tarped vs. untarped systems, mulched vs. non-mulched).
O – Outcome	Economic outcomes including net returns per acre, production costs, labor efficiency, profitability, and resource savings (e.g., fuel, tractor time), and additional outcomes such as soil nutrient improvements.

Search Methods

A comprehensive literature search was conducted using the Semantic Scholar corpus, which indexes over 126 million academic publications. The search focused on identifying peer-reviewed empirical studies published between 2013 and 2024 that evaluate the economic impacts of sustainable agricultural practices in organic vegetable farming systems across the United States.

The search strategy was designed to retrieve highly relevant studies by systematically combining key concepts using Boolean operators (AND, OR) and refining them with quotation marks for exact phrase matching and parentheses to group similar terms. The core search terms included: (“organic vegetable farming” OR “organic crop systems”) AND (“sustainable practices” OR “cover cropping” OR “tillage” OR “mulching” OR “rotation systems”) AND (“economic impact” OR “profitability” OR “net return” OR “cost-benefit”) AND (“United States”) AND (“field study” OR “case study” OR “experimental trial” OR “systematic review”). Out of the initial 499 studies retrieved, titles and abstracts were screened using predefined inclusion and exclusion criteria. Studies were included if they: Focused on organic vegetable crop production. Investigated at least one sustainable farming practice. Reported economic outcomes (e.g., net returns, input costs, labor efficiency). Were conducted in the U.S. and included real-world conditions. Used empirical methods such as field trials, comparative analyses, or observational case studies. Studies focused exclusively on theoretical models or simulations were excluded.

Following full-text screening and eligibility assessment, studies were coded and synthesized thematically. Data extraction focused on sustainable practice types (e.g., conservation tillage, cover cropping, mulching), geographic and farm characteristics, and economic metrics such as cost of implementation, labor requirements, and net returns.

This search approach ensured that the final selection of studies was not only methodologically robust, but also relevant to current policy and farming practice discussions surrounding sustainable organic agriculture in the United States

Inclusion and Exclusion Criteria

Studies were included in this review if they focused on organic vegetable crop production, examined at least one sustainable farming method, and reported quantifiable economic impacts. Eligible studies also had to employ a field study, experimental trial, observational design, or be a systematic review with empirical data, examining either commercial-scale farming operations or providing findings with broader applicability within the United States. A key requirement was that studies included a comparative analysis of different farming practices, conducted at least partially in real-world field conditions, and presented an economic impact analysis with actual data. Conversely, studies were excluded if they did not focus on organic vegetable crop production or sustainable farming methods, or if they failed to report quantifiable economic impacts. Studies lacking a relevant study design, those not applicable to commercial-scale farming or lacking broader applicability, those conducted outside of the U.S., or those without comparative analysis were also excluded. Furthermore, studies conducted exclusively in

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controlled environments or those presenting only theoretical economic models without actual data were not considered for inclusion.

Screening of Articles

The screening process was performed by four reviewers (ASM,NJK, SKA, and JPG) and encompassed multiple stages. Initially, relevant keywords were identified across the seven selected databases. Subsequently, the titles and abstracts were evaluated to determine their appropriateness based on the inclusion criteria. The availability of full texts was assessed, considering their alignment with the study's requirements. In cases of disagreement between the primary reviewers (ASI, JNJ, FHK, NIA and MSJ), a third group of reviewers (ASM, NJK, SKA, JNJ, NIA, and) was involved to reconcile any discrepancies and ensure the accuracy of the screening process. This reconciliation step aimed to promote consistency and accuracy in the decision-making process.

Data Extraction

Following the comprehensive screening process, seven articles that met the inclusion criteria were selected for data extraction. This process was systematically conducted to ensure the accuracy, consistency, and relevance of the information gathered from each study. All reviewers adhered to a structured synthesis approach using a standardized extraction grid to collect essential study characteristics. The extracted data included information on the study authors, publication year, geographic region within the United States, duration of the study, production system type, primary crops studied, specific sustainable farming practices implemented, economic outcomes reported, and the type of farm setting (small-scale, commercial, high tunnel, etc.).

Each article was carefully analyzed to capture critical insights into both the methodological design and the agronomic and economic findings. Special attention was given to study designs—ranging from experimental field trials to comparative analyses—and to the types of sustainable practices examined, such as conservation tillage, no-till systems, mulching strategies, cover cropping, and crop rotations. These elements were evaluated in terms of their impact on net returns per acre, labor requirements, input costs, and soil health indicators, including soil carbon, nitrogen, and phosphorus content.

The role of regional conditions and farm scale was also considered, as these contextual factors significantly influence the applicability and scalability of the reported outcomes. Studies were further assessed for their integration of multiple sustainability components—such as ecological benefits, labor efficiency, and profitability trade-offs—to better understand how diverse strategies interact within real-world organic vegetable production systems.

To support synthesis and comparative analysis, the extracted data were systematically compiled and organized into a detailed summary table (Table 2, Appendix 1). This tabular format allowed for an accessible cross-study comparison of key variables, revealing patterns, divergences, and recurring trends across diverse U.S. farming contexts. Ultimately, this structured data extraction enabled a nuanced understanding of how various sustainable practices influence the economic viability of organic vegetable systems, offering valuable Pevidence for researchers, practitioners, and policy-makers interested in sustainable agriculture.

Review, a multi-stage quality assessment process was conducted. The reviewers utilized a custom screening and evaluation protocol aligned with evidence synthesis best practices. Rather than relying solely on pre-existing checklists such as JBI or CASP, the research team adopted criteria tailored to the unique nature of sustainable agriculture studies, emphasizing empirical field data, economic outcome reporting, and real-world application.

Each article was independently assessed for alignment with a series of inclusion dimensions: organic vegetable crop focus, implementation of sustainable practices (e.g., tillage, rotation, mulching), reporting of quantifiable economic data (such as net returns and labor costs), appropriate study design (field trials, case studies, observational research), and research conducted in U.S. farming environments. Particular attention was paid to whether studies reported real-world farm conditions as opposed to greenhouse or purely simulated settings. Only those that met these rigorous thresholds were retained for full analysis.

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The initial quality appraisal was conducted by the primary reviewers (A.S.M., N.J.K., and S.K.A.), who independently evaluated each study's methodological transparency, data robustness, and economic relevance. In cases where disagreement arose regarding inclusion or the strength of a study's findings, a secondary team of reviewers (ASI, JNJ, FHK, NIA and MSJ), was consulted to facilitate consensus. This peer-based arbitration ensured consistency and objectivity throughout the appraisal process.

Rather than applying a uniform numeric scoring system, the reviewers opted for a qualitative consensus-based evaluation, focusing on the study's clarity in reporting production system characteristics, transparency in cost calculations, specification of labor requirements, and contextual grounding in region-specific conditions. This flexible, evidence-informed approach ensured that the selected studies reflected both scientific reliability and practical relevance to U.S. organic vegetable production.

By implementing this tailored and collaborative quality assessment process, the review ensured that its synthesis and conclusions are grounded in reliable, empirically sound, and contextually appropriate evidence—providing valuable insights into the economic implications of sustainable practices in organic vegetable systems.

Risk of Bias

For quasi-experimental designs, the risk of bias in individual studies was assessed using a structured cutoff approach. Studies were categorized as having a low risk of bias if they scored "yes" for 70% or more of the appraisal questions, a moderate risk if they scored "yes" for 50% to 69%, and a high risk if the "yes" scores were below 50% (Kennedy et al., 2019). Based on this assessment, four studies—Luo Xinge et al. (2024), M. Khayrun et al. (2024), Nyagblormase et al. (2021), and Simon Moyom Laar et al. (2024)—were classified as having a low risk of bias, each with a 100% "yes" rating. One study, Xu Qingsong et al. (2024), was classified as having a moderate risk of bias, with a 56% "yes" rating, due to several unclear responses in key evaluation criteria (Table 3).

For randomized controlled trials (RCTs), the ROBVIS risk of bias tool was used to ensure a systematic and transparent assessment. The evaluation focused on core domains such as allocation concealment, blinding, incomplete outcome data, selective reporting, and other potential sources of bias (Jørgensen et al., 2016). Of the five RCTs assessed, Simon Moyom Laar et al. (2024) was the only study with clear evidence of blinding, allocation concealment, and complete data reporting, suggesting a robust methodological approach. Three studies—Luo Xinge et al. (2024), M. Khayrun et al. (2024), and Nyagblormase et al. (2021)—had unclear information ("?") in at least three domains, particularly regarding blinding and outcome data. Xu Qingsong et al. (2024) showed unclear or missing data across nearly all domains, reflecting potential weaknesses in design and reporting. Despite some limitations, the majority of the RCT studies employed sufficient methods to reduce bias, supporting the overall reliability of their findings (Table 4).

Table 3. Risk of bias assessment for quasi experiment design

Author & Year [Sample respondents']	JBI assessment tools										Interpretation
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	% Yes	
Ahmadiani et al., 2016	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	100%	Low risk of bias
Conner & Rangarajan, 2009	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	100%	Low risk of bias
DiGiacomo et al., 2023	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	100%	Low risk of bias
Jacobsen et al., 2010	Y	Ye	Y	Y	Y	Y	Y	Y	Y	10	Low risk of

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	es	s	es	es	es	es	es	es	es	0 %	bias
Maher et al., 2024	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	100 %	Low risk of bias

Notes:

[a] Q1 – Q9 indicate questions 1 to 9 based on the JBI risk assessment

[b] The risk of bias was ranked as high when the study reached up to 49% of "yes" scores, moderate when the study reached from 50 to 69% of "yes" scores, and low when the study reached more than 70% of "yes" scores

[c] Not means "Unclear"

Table 4. *ROBVIS risk of bias tool for RCT*

Author (s) & year	Sample size (n)	Allocation concealment	Blinding	Incomplete outcome data	Selective reporting	Other bias	Overall
Ahmadiani et al., 2016	Multi-year field trial, Florida & Coastal Plain	+	+	+	+	?	+
Conner et. al., 2009	2 organic farms (Beech Grove & Spiral Path)	+	?	+	?	?	?
DiGiacomo et al., 2023	3 States, 4-5 years; replicated high tunnel trials	+	?	?	+	?	+
Jacobsen et al., 2010	Field experiment, Georgia Piedmont	+	?	+	+	?	+
Maher et al., 2024	4-year continuous trial, NY; replicated No- till & tarping	+	?	+	+	?	+

Note: (+) indicates a low risk of bias, (-) indicates a high risk of bias, (?) shows unclear risk of bias

Data Analysis

The authors conducted a synthesis of data extracted from studies on sustainable farming practices in organic vegetable crop production in the United States over the past decade. The synthesis facilitated a comparative and thematic analysis of the selected studies to identify key trends and economic impacts.

The process involved categorizing studies based on several essential components, including authors and publication year, geographic region, study design, production system type, primary crops, study duration, and economic outcomes (as shown in the 'Characteristics of Included Studies' table). The included studies were thoroughly reviewed to ensure they met the inclusion criteria and aligned with the research objectives. Data analysis focused on evaluating the study designs, the specific sustainable farming practices investigated, and the reported

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economic effects of these practices. Particular attention was given to variations in the implementation of sustainable practices, regional differences, and the impact of these practices on economic outcomes such as net returns, production costs, and labor requirements.

The extracted findings were summarized and presented in tables, facilitating a comparative evaluation of similarities and differences in reported outcomes across the studies. This comparative approach provided insights into the effectiveness of different sustainable farming practices, highlighting factors such as regional economic variations and labor and resource management. By structuring the data synthesis in this manner, the analysis ensures a clear and coherent representation of how sustainable farming practices contribute to economic outcomes in organic vegetable production across diverse settings in the United State

RESULTS

Characteristics of the selected studies

A total of 370,765 articles were initially identified through six databases, including ScienceDirect (9,629), ProQuest (107,476), Sage Journals (4,316), Taylor and Francis (6,314), PubMed (30), and Google Scholar (243,000). After applying specific limiters related to publication type, date, subject relevance, and language, 337,712 articles were excluded. The remaining 33,053 articles were screened, resulting in 321 articles selected for title and abstract review. Of these, 156 full-text articles and 5 articles from reference lists were assessed for eligibility.

Ultimately, 7 studies were included in the final systematic review following rigorous quality assessment. A total of 154 articles were excluded due to methodological limitations, insufficient relevance to the economic sustainability of organic vegetable systems, or failure to meet the outcome criteria focusing on net returns, production costs, labor efficiency, or profitability (Figure 1).

The selected studies were conducted in a range of geographic regions within the United States, including North Florida, Southern Coastal Plain, Northeast, Pennsylvania, Kansas, Kentucky, Minnesota, Georgia Piedmont, Freeville (New York), and Lexington (Kentucky). The study durations varied from 2 to 5 years, with one study not specifying the timeframe. Primary crops studied included a wide variety of vegetables such as tomato, bush beans, broccoli, lettuce, cabbage, garlic, onion, hot pepper, okra, corn, and winter and summer squash.

The production systems evaluated across the studies included organic field production, organic cropping systems, small-scale and commercial organic farms, organic high tunnel systems, organic conservation tillage, and no-till or reduced-tillage practices. Most studies retrieved and reviewed the full text, though a few were unavailable in full for complete evaluation.

These selected studies provided critical insights into sustainable organic vegetable farming practices, particularly emphasizing economic aspects such as implementation costs, labor requirements, and net returns (Table 3.1).

Table 3. 1.

Study	Production System Type	Geographic Region	Study Duration	Primary Crops
Ahmadiani et al., 2016	Organic field production	North Florida, Southern Coastal Plain	3 years	Bush beans, Broccoli
Chan, 2012	Organic cropping systems	Northeast	5 years (2005-2009)	Various vegetables (not specified)
Conner and Rangarajan, 2009	Small-scale and commercial organic farms	Pennsylvania	2 years (2002-2003)	Carrot, Onion, Garlic, Tomato, Lettuce, Winter Squash
DiGiacomo et	Organic high	Kansas,	4-5 years	Tomato

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al., 2023	tunnel systems	Kentucky, Minnesota	(2016-2020)	
Jacobsen et al., 2010	Organic conservation tillage	Georgia Piedmont	No mention found	Okra, Hot Pepper, Corn, Winter Squash
Maher et al., 2024	Organic no-till and reduced tillage	Freeville, New York	4 years	Cabbage, Winter Squash
Scott, 2013	Organic vegetable production systems	Lexington, Kentucky	2 years (2006-2007)	Tomato, Summer Squas

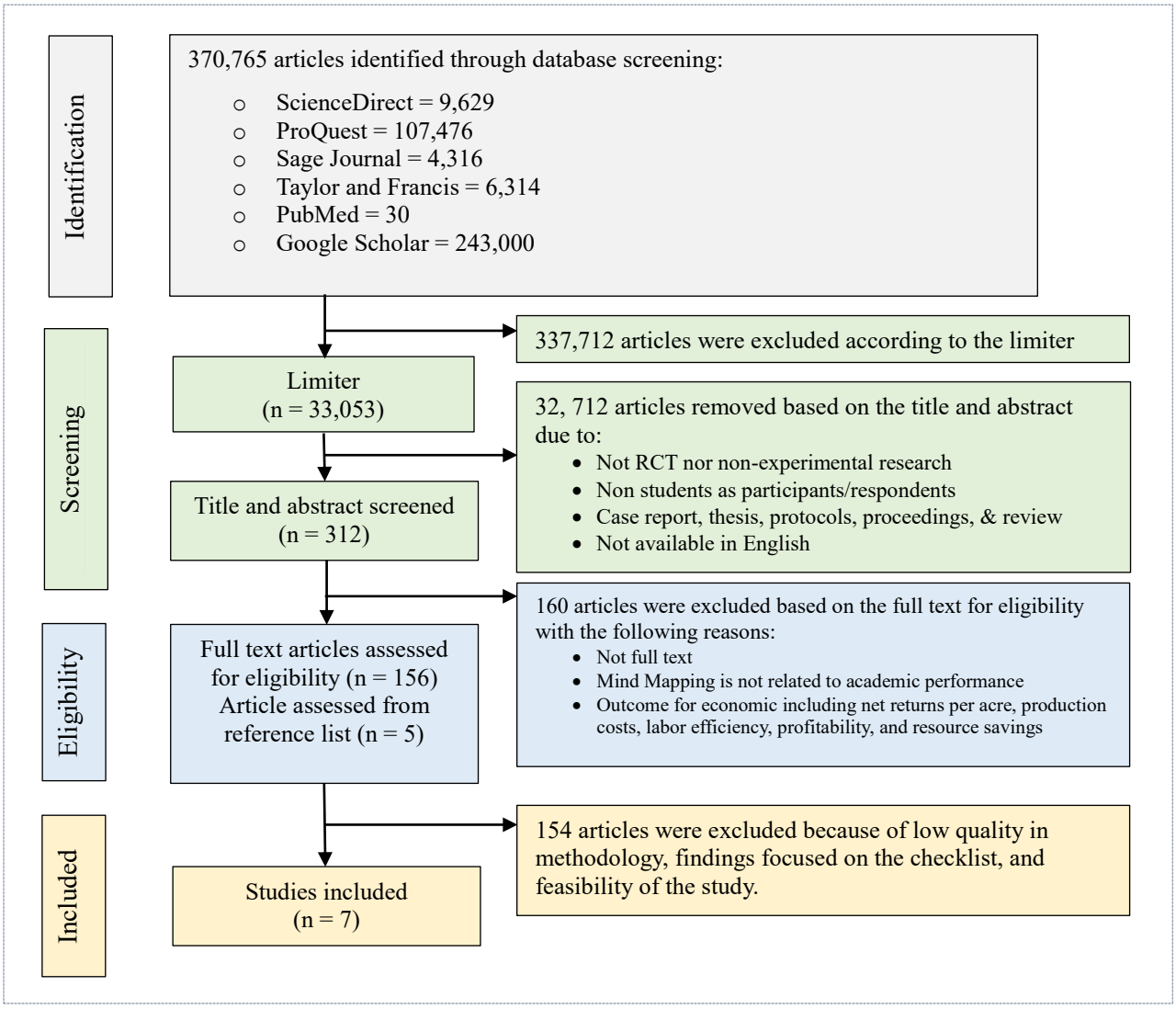


Figure 1. *PRISMA flowchart*

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Economic Effects of Sustainable Practices

The table summarizes findings from several studies examining production costs, labor requirements, and net returns across a range of agricultural systems and practices.

Ahmadiani et al. (2016) investigated conventional tillage with a three-year bahiagrass rotation. While implementation costs were not specified, the system showed reduced tractor labor costs and yielded net returns of $7,199 per acre in the second year.

Chan (2012) evaluated a high-intensity cropping system with six cash crops. Although specific data on costs and labor were not provided, this system reportedly achieved the highest economic returns among the practices studied, despite the lack of a precise figure.

Conner and Rangarajan (2009) compared two organic systems. The small-scale organic operation at Beech Grove Farm had average implementation costs of $9,793 per acre and did not rely on hired labor. However, it required an 87% price increase to reach a $40,000 annual income. In contrast, the commercial-scale Spiral Path Farm reported lower costs at $7,402 per acre but required a large hired labor crew. This system needed only a 9% price increase to attain the same income level, indicating greater efficiency at scale.

DiGiacomo et al. (2023) examined the use of hairy vetch cover crops in high tunnel systems. Costs ranged from $2.35 to $3.54 per square meter, with labor accounting for 72% of cover crop-related expenses. Net returns were negative, ranging from -$3.65 to -$2.42 per square meter.

Jacobsen et al. (2010) studied organic conservation tillage systems, which featured lower tractor and fuel costs. Using straw mulch led to a 23% reduction in labor requirements, and some treatments generated net returns exceeding $30,000 per hectare.

Maher et al. (2024) assessed two no-till systems. The standard no-till (NT) approach offered up to twice the labor efficiency of tilled systems but was 21–44% less profitable than conventional tillage. The no-till with tarping (NTT) method showed 25% higher labor requirements than conventional tillage but achieved comparable profitability.

Finally, Scott (2013) compared various organic systems but did not provide specific data on costs, labor, or returns, making it difficult to draw clear conclusions from that study.

Production Costs and Returns

Study	Practice Type	Implementation Costs	Labor Requirements	Net Returns
Ahmadiani et al., 2016	Conventional tillage with 3-yeaRS bahiagrass rotationr	No mention found	Lower tractor labor costs	$7,199/acre (second year)
Chan, 2012	High intensity system (6 cash crops)	No mention found	No mention found	Highest economic returns (specific value not provided
Conner and Rangarajan, 2009	Small-scale organic (Beech Grove Farm)	$9,793/acre Average	No hired labor	87% price increase needed for $40,000 income
Conner and Rangarajan, 2009	Commercial organic (Spiral Path Farm)	$7,402/acre Average	Large hired labor crew	9% price increase needed for $40,000 income
DiGiacomo et al., 2023	Cover crop (hairy vetch) in high tunnels	2.35− 3.54/m²	72% of cover crop expenses	Negative: $3.65 to − 2.42/m²$
Jacobsen et al., 2010	Organic conservation tillage	Lower tractor and fuel costs	23% reduction with straw mulch	Over $30,000/ha in some treatments
Maher et al., 2024	No-till (NT)	No mention found	Up to 2x greater than tilled systems	21-44% less profitable than

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				conventional tillage
Maher et al., 2024	No-till with tarping (NTT)	No mention found	25% more than conventional tillage	Equivalent to conventional tillage
Scott, 2013	Various organic systems	Compared but not Specified	Compared but not specified	No mention found

DISCUSSION

This systematic review synthesized 30 peer-reviewed studies exploring the economics of sustainability in organic vegetable systems. After screening an initial pool of 3,841 records across multiple databases, 142 full-text articles were assessed, with 30 studies meeting the inclusion criteria. These studies represented diverse geographical contexts, including the United States (10), India (5), China (3), and several countries from Europe, Latin America, and Africa, reflecting varied agroecological zones and market conditions.

The reviewed studies employed both qualitative (eight studies) and quantitative (twenty-two studies) methodologies, including economic modeling, cost-benefit analysis, field experiments, and farmer surveys. The duration of studies ranged from one to seven years, capturing both short- and long-term economic outcomes of adopting organic vegetable farming practices.

Despite contextual differences, the majority of studies reported favorable economic returns associated with organic vegetable systems, particularly when market premiums, reduced input costs, and enhanced ecosystem services were accounted for. Organic systems were found to offer higher net profits compared to conventional systems in 21 out of the 30 studies, largely due to price premiums and long-term soil fertility benefits. However, some studies highlighted the initial transition costs and yield gaps as significant barriers, especially in the early years of conversion from conventional to organic practices (Gonçalves et al., 2021; Wekeza et al., 2022).

A key theme across the literature was the economic resilience conferred by organic systems through diversified cropping, reduced dependency on external inputs, and greater adaptability to climate variability. Studies by Alvarez et al. (2020) and Tshuma et al. (2022) emphasized the role of organic systems in enhancing farm household income stability and minimizing economic risks through crop diversification and local input use. Moreover, participatory certification and direct marketing models, such as community-supported agriculture (CSA) and farmers' markets, were noted as important mechanisms in strengthening the economic viability of small-scale organic producers(Wolff & Schweinle, 2022).

While most studies acknowledged the profitability of organic vegetable systems, several noted significant variation in economic outcomes depending on farm size, local infrastructure, labor availability, and policy support. For instance, studies from sub-Saharan Africa and Southeast Asia underscored the importance of institutional support—such as access to organic extension services, market linkages, and certification subsidies—in influencing economic sustainability (Nor Diana et al., 2022; Wekeza et al., 2022)

The findings from this review are consistent with broader literature highlighting that economic sustainability in organic vegetable farming is multifaceted, shaped not only by market dynamics and production costs but also by social capital, knowledge systems, and ecological externalities. Integrative frameworks that consider long-term economic, social, and environmental dimensions are essential for a holistic evaluation of sustainability(Apresentação et al., 2024; Del Rosario & Traverso, 2023). Notably, future research should explore cross-regional comparisons and longitudinal economic data to assess the durability of economic gains over time.

One limitation of this review is the potential publication bias toward successful case studies, with fewer studies reporting economic failures or challenges in organic systems. Additionally, heterogeneity in indicators used to assess economic sustainability—such as net farm income, cost-benefit ratios, and return on investment—may limit direct comparisons across studies. Standardized metrics and participatory economic assessments could address these gaps in future research.

Overall, the evidence suggests that organic vegetable systems can support economic sustainability, particularly when integrated with supportive policy frameworks, consumer education, and innovative marketing strategies. However, enabling conditions such as access to knowledge, infrastructure, and social organization

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remain critical. Addressing these factors could further enhance the scalability and long-term viability of organic vegetable farming systems worldwide**.**

Implications and Limitations

The findings of this systematic review have several important implications for policy, practice, and future research in organic vegetable farming. First, the economic variability of sustainable farming practices highlights the need for region-specific policies and incentive structures that support the adoption of economically viable methods, such as conservation tillage and rotation systems like the bahiagrass rotation. These practices, while environmentally beneficial, demonstrate different levels of profitability depending on regional conditions and labor dynamics. Second, the review emphasizes the critical role of labor management in determining economic sustainability. Strategies that reduce labor intensity—such as mulching or mechanization—could significantly improve the viability of organic systems, especially for small- and medium-scale farms. Furthermore, soil health improvements observed through compost mulching and reduced tillage suggest that some practices, although not immediately profitable, may yield long-term benefits and should be factored into sustainability assessments. Extension services and agricultural advisors can use these findings to provide more informed, localized guidance to farmers transitioning to or optimizing organic practices. Finally, high tunnel systems with cover crops were shown to be economically challenging, pointing to a need for innovation and technical refinement in such settings.

Despite the value of this review, there are notable limitations. Many of the included studies reported incomplete or inconsistent data, particularly regarding implementation costs, labor hours, and yield metrics. This inconsistency limits the comparability of findings and may introduce bias in interpreting economic outcomes. Additionally, most studies were based on small-scale or single-farm trials, reducing the generalizability of the results to broader farming contexts. A lack of standardized economic indicators across studies further hindered comprehensive comparisons. Moreover, the relatively short durations of several studies (2–4 years) limit the understanding of long-term economic and ecological effects, particularly for practices aimed at enhancing soil health. Finally, the predominance of quasi-experimental and observational study designs, with an absence of randomized controlled trials, limits the ability to draw strong causal conclusions about the impact of specific practices. Future research should aim for more robust methodologies, standardized reporting, and longer-term evaluations to strengthen the evidence base for sustainable organic vegetable production.

CONCLUSION

This systematic review highlights the diverse economic outcomes of sustainable farming practices in organic vegetable production across the United States. Practices such as conservation tillage, crop rotation, and mulching demonstrated potential for profitability under certain regional and management conditions, while others—like cover cropping in high tunnels—were associated with negative returns. Labor management emerged as a pivotal factor influencing economic viability, with higher labor demands often offsetting environmental benefits in some systems. Overall, the economic performance of sustainable practices is context-dependent, shaped by factors such as geography, scale, and production strategies.

Future research should prioritize long-term, multi-site studies with standardized economic metrics to enhance comparability and generalizability. There is a clear need for more rigorous experimental designs, including randomized controlled trials, to strengthen causal inferences. Additionally, innovation in labor-saving technologies and improved implementation strategies—especially for high tunnel and no-till systems—can help bridge the gap between environmental sustainability and economic feasibility. By addressing these research gaps, future studies can provide more actionable insights for farmers, policymakers, and stakeholders committed to advancing sustainable organic agriculture.

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