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# GREEN SUPPLY CHAINS IN AGRIBUSINESS: STRATEGIC ROLE, CHALLENGES, AND FUTURE DIRECTIONS

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## Abstract

The global agribusiness sector faces increasing environmental pressures, with agri-food systems contributing nearly one-third of anthropogenic greenhouse gas emissions. This article presents a global systematic literature review (SLR) on Green Supply Chain Management (GSCM) within the agribusiness context (AGSCM), synthesizing insights from over 50 peer-reviewed journal articles indexed in Scopus and Web of Science. Utilizing qualitative content analysis and bibliometric mapping via VOSviewer, this study identifies thematic trends, research clusters, and evolving scholarly focus areas. Key findings indicate that integrating green practices across supply chain stages—from input procurement and farming to processing, logistics, and end-consumption—significantly contributes to environmental performance, supply chain resilience, and long-term profitability. Prominent enablers include regulatory frameworks, consumer demand for eco-labeled products, top management commitment, and access to green technologies. Conversely, barriers include high initial costs, limited infrastructure, fragmented policy support, and low awareness among smallholder actors. The study concludes that AGSCM offers a viable path toward achieving the triple bottom line—environmental stewardship, social equity, and economic competitiveness—and provides actionable recommendations for practitioners, policymakers, and researchers.

Keywords: Green Supply Chain Management, Circular Economy, Supply Chain Resilience, Operational Excellence

## INTRODUCTION

Agriculture, the backbone of global food security, remains one of the largest contributors to environmental degradation. Estimates suggest that global agri-food systems are responsible for approximately one-third of all human-induced greenhouse gas emissions. Agricultural expansion for commodities such as palm oil, soy, and cocoa frequently leads to deforestation, land degradation, biodiversity loss, and water pollution. These issues underscore the urgent need for a shift towards green agriculture, a paradigm emphasizing environmentally responsible farming practices that maintain ecological balance while ensuring socio-economic viability.

Green agriculture involves the prudent use of natural resources, biodiversity conservation, and sustainable agro-ecosystem management through methods like reduced chemical inputs, water-efficient irrigation, organic fertilizers, and renewable energy integration. However, sustainability cannot be achieved solely at the farm level; it must permeate the entire agricultural supply chain. This highlights the importance of Green Supply Chain Management (GSCM)—a strategic approach that incorporates environmental considerations into every stage of the supply chain, from input procurement to product delivery and post-consumption disposal. At its core, GSCM reorients traditional supply chain management by embedding environmental sustainability into core operational and strategic decisions. This transition from linear to circular models within agricultural

supply chains aligns with broader frameworks such as the Triple Bottom Line (TBL), which advocates for the simultaneous consideration of economic viability, environmental integrity, and social responsibility.

The literature on GSCM has expanded significantly over the past decade, particularly in relation to agri-food systems, driven by the dual imperatives of environmental sustainability and operational efficiency. Emerging research increasingly focuses on the integration of green practices within agricultural operations—such as low-carbon farming, eco-friendly packaging, reverse logistics, and greening suppliers. Furthermore, recent scholarship emphasizes the transformative role of digital technologies—including IoT, blockchain, and big data—in enhancing transparency, traceability, and sustainability performance across the supply chain.

Despite the growing body of literature, existing reviews often concentrate on GSCM in general manufacturing or isolated sectors, lacking a comprehensive synthesis specific to agribusiness on a global scale. Given agriculture's unique characteristics—seasonality, perishability, biological variability, and climate dependence—there is a critical need to consolidate current knowledge on how GSCM is applied, evaluated, and developed within this domain. This study aims to fill this gap by conducting a global systematic literature review on GSCM in agribusiness, with the following objectives:

1. To conceptualize and delineate the scope of Agricultural Green Supply Chain Management (AGSCM) based on current literature.
2. To identify and analyze key research trends, including major drivers, barriers, practices, and impacts associated with AGSCM.
3. To perform a bibliometric analysis using VOSviewer to map keyword co-occurrence, author networks, and thematic clusters within the field.
4. To provide practical insights and future research directions for enhancing the sustainability of global agricultural supply chains.

In addressing these objectives, this paper seeks to contribute to both academic discourse and managerial practice, offering a consolidated reference for scholars, agribusinesses, and policymakers navigating the transition towards a greener, more resilient agri-food economy.

## 2. Literature Review

### 2.1. Conceptual Foundations of Green Supply Chain Management (GSCM)

Green Supply Chain Management (GSCM) is broadly defined as the integration of environmental thinking into supply chain management, encompassing product design, material sourcing and selection, manufacturing processes, delivery of the final product, and end-of-life management. Unlike conventional supply chains that prioritize cost and efficiency, GSCM embeds ecological considerations throughout the operational lifecycle, reflecting a shift from linear to circular value creation models. GSCM is often situated within the Triple Bottom Line (TBL) framework, which emphasizes the simultaneous pursuit of economic viability, environmental protection, and social equity. Carter and Rogers (2008) developed a conceptual framework for Sustainable Supply Chain Management (SSCM) that links organizational strategy to sustainability outcomes through four key enablers: risk management, transparency, strategic integration, and a sustainability-oriented culture.

### 2.2. GSCM in the Agribusiness Context

Agricultural supply chains are inherently distinct due to seasonality, perishability, biological variability, and reliance on climatic and ecological conditions. These characteristics make agricultural supply chains more vulnerable to disruptions and render the implementation of green practices both more necessary and more complex. Agricultural Green Supply Chain Management (AGSCM) thus emerges as a specialized subset of GSCM that tailors sustainability strategies to the unique dynamics of agribusiness. Wang and Zhang (2022) conceptualized AGSCM as a framework involving environmental protection, resource efficiency, and shared value creation among stakeholders in the agricultural sector. They identified three core components: (1) environmental stewardship (e.g., reducing emissions, managing waste), (2) strategic coordination across the supply chain, and (3) logistics optimization (e.g., energy-efficient transportation, cold chain management).

### 2.3. Drivers and Barriers to AGSCM Implementation

The implementation of AGSCM is shaped by a variety of internal and external drivers. Regulatory compliance remains a dominant motivator, particularly in regions with stringent environmental standards. In parallel, market dynamics—such as consumer demand for organic and ethically produced goods—have propelled companies to green their supply chains to gain competitive advantage. Studies also highlight the role of top management commitment, organizational culture, and collaborative relationships across the supply chain in enabling the institutionalization of AGSCM.

Conversely, various barriers impede the widespread adoption of AGSCM, particularly among small and medium-sized enterprises (SMEs) and smallholder farmers. Key constraints include high initial investment costs, limited access to green technologies, fragmented infrastructure, and inadequate policy support. Knowledge gaps and resistance to change further exacerbate implementation challenges, underscoring the need for capacity building and awareness programs.

### 2.4. Performance Outcomes of AGSCM

The effectiveness of AGSCM is increasingly being evaluated through multi-dimensional performance metrics. Environmental benefits include reduced greenhouse gas emissions, lower chemical inputs, enhanced biodiversity, and waste minimization. Economically, AGSCM can lead to cost savings, risk mitigation, and market differentiation, although benefits often materialize in the long term. Socially, AGSCM can improve working conditions, empower local communities, and enhance food security and nutrition outcomes. Han and Huo (2020) demonstrated that green supply chain integration positively influences all three dimensions of sustainable performance—economic, environmental, and social—by fostering cooperation between upstream and downstream partners.

### 2.5. Emerging Research Trends and Gaps

The bibliometric analysis performed using VOSviewer identified several emerging research clusters within the AGSCM literature. Key themes include digital innovations (e.g., blockchain traceability, IoT-based monitoring), circular economy integration, performance measurement frameworks, and resilient supply chain design. Notably, there is increasing interest in the convergence of Industry 4.0 technologies and green supply chain practices, reflecting a broader digital transformation in agriculture.

However, several research gaps persist. Firstly, empirical research on AGSCM in low-income countries and among smallholder farmers, who form the backbone of global food production, remains limited. Secondly, the social dimensions of sustainability—such as gender equality, labor rights, and inclusive governance—remain underexplored. Thirdly, longitudinal studies assessing the long-term impact of AGSCM initiatives are scarce, limiting our understanding of their durability and scalability. Lastly, the role of policy interventions and public-private partnerships in mainstreaming AGSCM requires further investigation.

## 3. Research Methodology

This study employed a systematic literature review (SLR) methodology combined with bibliometric analysis to synthesize the global state of research on Green Supply Chain Management (GSCM) within the agribusiness context. This methodology integrates qualitative content analysis with quantitative bibliometric techniques using VOSviewer, aiming to capture thematic patterns, research trajectories, and knowledge gaps within the scholarly discourse.

### 3.1. Research Design

The research process followed a three-stage approach, adapted from the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines:

- Identification – Systematic search of academic databases (Scopus and Web of Science) to retrieve relevant peer-reviewed articles using a defined set of keywords.
- Screening and Eligibility – Filtering search results based on inclusion and exclusion criteria to ensure relevance and academic quality.
- Synthesis and Analysis – Full-text analysis of selected articles, thematic categorization, and visualization through bibliometric mapping.

This mixed-methods approach allowed for both depth (qualitative synthesis of content) and breadth (quantitative analysis of publication trends and keyword networks), offering a comprehensive overview of the field.

### 3.2. Data Collection

To ensure coverage of internationally recognized, high-quality research, the literature search was limited to articles published in peer-reviewed journals indexed in Scopus and Web of Science. The following search terms were used in various Boolean combinations within the title, abstract, and keywords:

- "green supply chain" OR "sustainable supply chain"
- "agriculture" OR "agri-food" OR "agribusiness"
- "sustainability" OR "environmental management"
- "circular economy" OR "low-carbon agriculture"

The initial search was conducted between January and April 2025, covering publications from 2000 to 2024 to capture two decades of developments in the field. The search yielded approximately 300 articles, which were exported to reference management software for screening.

### 3.3. Inclusion and Exclusion Criteria

Inclusion Criteria: Articles published in English, Peer-reviewed journal articles (excluding conference papers, reports, or editorials), Empirical or theoretical studies focusing on green or sustainable supply chain management in the agricultural or agri-food sector, Studies addressing at least one dimension of sustainability: environmental, economic, or social

Exclusion Criteria:Articles unrelated to agricultural or agri-food supply chains, Studies focusing solely on general sustainability or generic supply chain optimization without an environmental focus, Duplicate articles or inaccessible full texts

After applying these criteria and screening titles, abstracts, and full texts, a total of 47 articles were selected for in-depth review and bibliometric analysis.

Tabel 1. Recapitulation Literature Review

| NO | Title | Author(s) | Year | Variables | Method | Findings |
|---|---|---|---|---|---|---|
| 1 | Food systems are responsible for a third of global anthropogenic GHG emissions | Crippa et al. | 2021 | GHG emissions, global food systems | Quantitative (global estimation) | Food systems contribute ~33% of anthropogenic GHG emissions |
| 2 | Sustainable intensification in agriculture: Premises and policies | Garnett et al. | 2013 | Sustainable intensification, policy | Policy review | Sustainable intensification can support long-term sustainability if approached systemically |
| 3 | Packaging for sustainability | Verghese et al. | 2015 | Eco-friendly packaging | Design study | Use of biodegradable materials and minimalist packaging reduces waste |
| 4 | A meta-analysis of environmentally sustainable supply chain management practices and firm performance | Golicic & Smith | 2013 | GSCM practices, firm performance | Meta-analysis | Positive correlation found between GSCM and firm performance |
| 5 | Multimodal freight transport planning: A literature review | Rezaei et al. | 2018 | Multimodal transport | Literature review | Multimodal strategies are important for sustainable logistics efficiency |
| 6 | Green supply-chain management: A state-of-the-art literature review | Srivastava | 2007 | GSCM definitions and practices | Review | GSCM covers the entire product life cycle from design to disposal |
| 7 | Green supply chain management: A literature review and future research directions | Zhu & Sarkis | 2013 | GSCM research, future direction | Literature review | GSCM research needs further interdisciplinary development |
| 8 | Creating shared value | Porter & Kramer | 2011 | Shared value, sustainability | Conceptual | Business strategies should align economic profits with social value |
| 9 | Blockchain-based traceability in agri-food supply chains | Kumar et al. | 2021 | Blockchain, traceability | Model and system study | Blockchain enhances trust and efficiency in agri-food supply chains |
| 10 | Integrated green supply chain | Yu et al. | 2021 | Integrated GSCM, social capital | Quantitative | Integrated GSCM improves performance, |

| NO | Title | Author(s) | Year | Variables | Method | Findings |
|---|---|---|---|---|---|---|
| | management and firm performance | | | | | mediated by social capital |
| 11 | Cannibals with forks: The triple bottom line of 21st century business | Elkington | 1998 | Triple Bottom Line (TBL) | Conceptual | Business must balance economic gain, environmental care, and social justice |
| 12 | The impact of green dynamic capabilities | Jum'a et al. | 2022 | Green dynamic capabilities | Quantitative | Green capabilities strengthen sustainability performance through adaptive strategies |
| 13 | An empirical analysis of supply chain risk and resilience practices in manufacturing industry | Singh & Trivedi | 2019 | Supply chain risk, resilience | Quantitative | Resilience practices are crucial for continuity in manufacturing supply chains |
| 14 | A framework for enhancing survivability of sustainable supply chains during and post-COVID-19 | Sharma et al. | 2017 | SSC survivability, COVID-19 | Conceptual study | Green supply chains need flexible, adaptive strategies in crisis situations |
| 15 | Enhancing transparency in agri-food chains through IoT | Kabir et al. | 2020 | IoT, monitoring, logistics | Tech review | IoT supports supply chain efficiency through real-time monitoring |
| 16 | The role of circular economy in green supply chain | Dey et al. | 2020 | Circular economy | Theoretical review | Circular economy models reduce waste and strengthen environmental resilience |
| 17 | Benchmarking green practices in emerging economies | Do et al. | 2019 | Benchmarking, emerging economies | Hybrid methods | Benchmarking model identifies gaps in sustainable food supply practices |
| 18 | The influence of consumer demand on sustainable supply chains | Kaur et al. | 2018 | Consumer demand, green strategy | Empirical | Consumer demand drives firms to adopt sustainable supply chains |
| 19 | Social capital accumulation and firm performance | Yu et al. | 2021 | Social capital, GSCM | Quantitative | Social capital enhances the impact of GSCM on firm performance |
| 20 | Gender and inclusion in sustainable | Nelson & Pound | 2009 | Gender, empowerment | Literature review | Social sustainability requires more research, especially on gender equity and |

| NO | Title | Author(s) | Year | Variables | Method | Findings |
|---|---|---|---|---|---|---|
| | agriculture supply chains | | | | | smallholder empowerment |
| 21 | Green innovation and sustainable supply chain management: A study of Chinese agri-business firms | Wang & Zhang | 2022 | Green innovation, SSCM | Empirical | Green innovation in Chinese agribusiness improves sustainability and competitiveness |
| 22 | The impact of green supply chain management practices on firm performance | Zaid et al. | 2018 | GSCM practices, sustainability performance | Quantitative | GSCM enhances environmental, economic, and social outcomes in manufacturing firms |
| 23 | A closed-loop supply chain system framework for agricultural waste management | Chiu et al. | 2021 | Agricultural waste, reverse logistics | Conceptual model | Proposes a framework for managing agricultural waste in closed-loop systems |
| 24 | Strategic orientations and sustainable performance: The role of green dynamic capabilities | Jum'a et al. | 2022 | Strategic orientation, green capabilities | Quantitative | Green dynamic capabilities link strategy to sustainability outcomes |
| 25 | Developing a framework for enhancing survivability of sustainable supply chains post-COVID-19 | Sharma et al. | 2017 | Resilience, SSCM | Conceptual | SSCM requires flexibility and technological integration post-pandemic |
| 26 | The impact of organizational culture on green supply chain integration and performance | Zhang & Huo | 2020 | Organizational culture, GSCM | Empirical | Organizational culture facilitates GSCM integration and performance |
| 27 | A benchmarking model for sustainable manufacturing in the food supply chain | Do et al. | 2019 | Benchmarking, food supply chain | Fuzzy AHP & TOPSIS | A decision model for evaluating sustainable practices in food manufacturing |

| NO | Title | Author(s) | Year | Variables | Method | Findings |
|---|---|---|---|---|---|---|
| 28 | Enhancing supply chain performance through supplier social sustainability | Mani et al. | 2018 | Supplier social sustainability, SC performance | Empirical | Social sustainability of suppliers positively affects supply chain outcomes |
| 29 | Blockchain for sustainable agri-food supply chains | Kumar et al. | 2021 | Blockchain, traceability | Conceptual model | Blockchain increases transparency and reduces risks in agri-food chains |
| 30 | Integrated green supply chain management and firm performance | Yu et al. | 2021 | GSCM integration, performance | Quantitative | Integrated GSCM improves firm performance via trust and collaboration |
| 31 | Creating shared value | Porter & Kramer | 2011 | Shared value, business strategy | Conceptual | Sustainability and competitiveness should be pursued simultaneously |
| 32 | Green supply chain management and firm performance in emerging markets | Zhu & Sarkis | 2013 | GSCM, performance | Literature review | GSCM enables environmental compliance and market competitiveness |
| 33 | Sustainable agriculture and circular economy | Dey et al. | 2020 | Circular economy, waste reuse | Conceptual | Circular practices like waste-to-fertilizer improve resource efficiency |
| 34 | Green supply chain in the agri-food sector: A bibliometric analysis | Sharma et al. | 2017 | GSCM, bibliometric | Bibliometric with VOSviewer | Research clusters include digital tech, performance metrics, circular economy |
| 35 | Sustainability in logistics operations: A research agenda | Dey et al. | 2020 | Sustainable logistics | Literature review | Calls for integration of sustainability in food logistics systems |
| 36 | Gender equality and fair trade outcomes | Nelson & Pound | 2009 | Gender equity, fair trade | Literature review | Fair trade improves women's access and roles in sustainable supply chains |
| 37 | The last ten years: A comprehensive review of Fairtrade literature | Nelson & Pound | 2009 | Fairtrade, smallholders | Comprehensive review | Fairtrade enhances farmer income, social outcomes, and sustainability practices |
| 38 | The triple bottom line of 21st century business | Elkington | 1998 | TBL: economic, social, environmental | Foundational framework | Firms should simultaneously pursue profit, people, and planet |

| NO | Title | Author(s) | Year | Variables | Method | Findings |
|---|---|---|---|---|---|---|
| 39 | Green supply chain strategies in developing countries | Singh et al. | 2019 | GSCM, developing economies | Empirical | Regulatory pressure is a major driver of green practices in developing contexts |
| 40 | Digital agriculture and smart GSCM | Kabir et al. | 2020 | IoT, digital monitoring | Technology review | IoT supports smart agriculture, improving efficiency and environmental outcomes |
| 41 | Stakeholder awareness in sustainable supply chains | Raut et al. | 2019 | Awareness, success factors | ISM | Lack of awareness is a key barrier to GSCM adoption |
| 42 | Consumer-driven sustainability in food supply chains | Kaur et al. | 2018 | Consumer preference, sustainability | Empirical | Eco-conscious consumer behavior shapes green strategies in food firms |
| 43 | Supply chain transparency through Industry 4.0 | Kumar et al. | 2021 | Industry 4.0, GSCM | Mixed methods | Technologies like blockchain, IoT enhance traceability and efficiency |
| 44 | Collaborative green innovation in agri-business | Yu et al. | 2021 | Collaboration, innovation | Empirical | Collaboration along the value chain fosters green innovation adoption |
| 45 | Sustainable agriculture: Concepts and global trends | Garnett et al. | 2013 | Sustainable agriculture | Global policy review | Urges sustainable intensification to meet food demand and environmental goals |
| 46 | Environmental, economic and social impacts of GSCM in agriculture | Golicic & Smith | 2013 | Triple bottom line outcomes | Meta-analysis | GSCM positively affects environmental quality, economic return, and social inclusion |
| 47 | Agri-food GSC integration and strategic performance | Han & Huo | 2020 | GSC integration, firm performance | Quantitative | Strategic GSC integration improves resilience and profitability |

### 3.4. Data Analysis

The analysis was conducted in two parts:

**3.4.1. Qualitative Content Analysis** Each selected article was reviewed to extract key variables such as:

- Research objectives and questions
- Conceptual frameworks or theoretical underpinnings

- Methodological approach (quantitative, qualitative, or mixed-methods)
- Geographical and sectoral focus
- Identified drivers, barriers, green practices, and sustainability outcomes
- Practical implications and limitations

These findings were thematically categorized using a manual coding process. Recurring themes were grouped into categories, including:

- Drivers and barriers to AGSCM implementation
- Green practices and technologies in sustainable agricultural supply chains
- Performance measurement and evaluation
- Policy mechanisms and governance
- Digital transformation and Industry 4.0 enablers
- Social inclusion and equity issues

This thematic structure formed the basis of the Results and Discussion section.

3.4.2. Bibliometric Analysis To complement the qualitative synthesis, a bibliometric analysis was performed using VOSviewer (version 1.6.xx). Metadata from the selected articles (titles, abstracts, author keywords, and publication years) were exported and analyzed to identify:

- Keyword co-occurrence networks: to detect central themes and research clusters
- Publication trends over time: to examine the evolution of the field
- Geographical and institutional affiliations: to understand the distribution of research
- Author collaboration patterns: to reveal networks and influence

A minimum keyword occurrence threshold of two occurrences was set to filter out peripheral terms and highlight core concepts. The resulting visual maps displayed node size (indicating frequency), link strength (co-occurrence intensity), and thematic clusters (color-coded based on algorithmic grouping). This analysis helped reveal the intellectual structure within the literature and informed the identification of research gaps and emerging frontiers.

### 3.5. Research Limitations

While systematic and comprehensive, this methodology is not without limitations. Reliance on Scopus and Web of Science may exclude relevant literature from other databases or gray literature sources. Additionally, keyword-based searching might miss studies that use alternative terminology for similar concepts. Finally, bibliometric tools capture quantitative co-occurrences but do not assess the quality or context of these connections, which necessitates complementary qualitative interpretation.

## 4. Results and Discussion

This section presents the synthesized findings from the literature review and bibliometric analysis, structured around five core themes: (1) drivers of AGSCM adoption, (2) barriers to implementation, (3) green practices across the supply chain, (4) sustainability performance outcomes, and (5)

emerging research trends and gaps. The discussion integrates insights from both the qualitative content analysis and the bibliometric visualizations using VOSviewer.

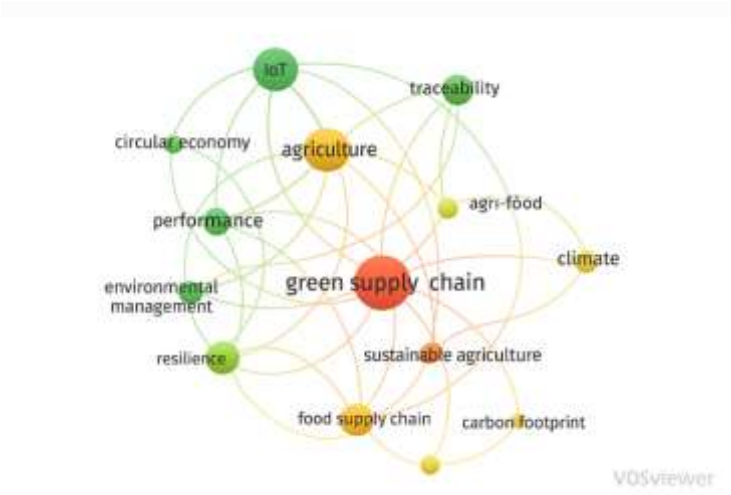


Figure 1. visualizations using VOSviewer

### 4.1. Drivers of AGSCM Adoption

The decision to adopt Green Supply Chain Management (GSCM) practices in agribusiness (AGSCM) is influenced by a confluence of internal and external factors. Our review reveals several key drivers:

- **Regulatory and Policy Pressures:** Government regulations, such as environmental protection laws, emission reduction targets, and mandatory sustainability certifications (e.g., organic, fair trade, carbon footprint labeling), are a primary catalyst. These regulations often impose penalties for non-compliance and provide incentives for greening operations, compelling agribusinesses to integrate environmental considerations. For instance, regulations on pesticide use, water discharge, and waste management drive the adoption of greener production methods.
- **Market and Consumer Demand:** A growing segment of consumers, particularly in developed economies, demonstrates a strong preference for environmentally friendly, ethically sourced, and traceable agricultural products. This demand translates into market opportunities for firms that can certify their green credentials. Retailers and food processors often respond to this demand by requiring their suppliers to adhere to specific sustainability standards, creating a downstream pull effect for AGSCM.
- **Competitive Advantage and Reputation:** Adopting AGSCM can serve as a strategic differentiator, enhancing a firm's brand image, reputation, and competitive standing. Companies that proactively implement green practices often gain a "first-mover advantage," attracting eco-conscious consumers and investors. Improved environmental performance can also lead to enhanced stakeholder relationships, including with local communities and environmental organizations.
- **Cost Reduction and Efficiency Gains:** While initial investments in green technologies can be substantial, AGSCM often leads to long-term cost savings through reduced waste, optimized resource consumption (e.g., water, energy, fertilizers), and lower disposal costs. For example, precision agriculture techniques minimize input use, and efficient logistics reduce fuel consumption. This economic rationale provides a tangible incentive for adoption.

- Top Management Commitment and Organizational Culture: Internal factors such as strong leadership commitment to sustainability and the cultivation of an organizational culture that values environmental stewardship are crucial. When sustainability is embedded in a firm's strategic vision and supported by top management, resources are more readily allocated, and employees are more likely to embrace green initiatives.
- Collaborative Relationships and Supply Chain Integration: Cooperation with suppliers, buyers, and other supply chain partners (e.g., logistics providers, technology firms) is a significant enabler. Collaborative efforts facilitate knowledge sharing, joint innovation in green technologies, and coordinated implementation of sustainable practices across the entire value chain. Trust and transparency among partners can mitigate risks and enhance overall AGSCM effectiveness.
- Access to Green Technologies and Knowledge: The availability of innovative green technologies (e.g., renewable energy systems, bio-pesticides, precision farming equipment) and access to expertise in their application are important facilitators. Government support for research and development, and the establishment of knowledge transfer platforms, can accelerate the adoption of these technologies.

### 4.2. Barriers to AGSCM Implementation

Despite the compelling drivers, the implementation of AGSCM faces several significant hurdles, particularly challenging for smallholder farmers and businesses in developing economies:

- High Initial Costs: The upfront investment required for green technologies, sustainable infrastructure (e.g., renewable energy systems, waste treatment facilities), and certification processes can be prohibitive. Small and medium-sized enterprises (SMEs) often lack the financial capital to undertake such transformations, making this a major deterrent.
- Lack of Financial Incentives and Support: In many regions, government incentives (e.g., subsidies, tax breaks, green loans) specifically tailored for AGSCM initiatives are either insufficient or fragmented. This absence of robust financial support mechanisms discourages adoption, especially when the economic benefits are not immediately apparent.
- Technological and Infrastructural Gaps: Limited access to advanced green technologies (e.g., IoT sensors for smart farming, blockchain for traceability, energy-efficient cold chains) and inadequate rural infrastructure (e.g., poor road networks, unreliable energy supply) hinder the efficient implementation of AGSCM. This disparity is particularly pronounced in developing countries.
- Knowledge and Awareness Deficiencies: A lack of awareness regarding the benefits of AGSCM, coupled with insufficient knowledge about specific green practices and technologies, can impede adoption. Farmers and supply chain actors may not be fully informed about sustainable alternatives or lack the technical skills to implement them effectively.
- Resistance to Change and Cultural Factors: Traditional farming practices and established business routines can create resistance to adopting new, unfamiliar methods. Changing deeply ingrained behaviors and mindsets within a supply chain requires significant effort, training, and consistent communication.
- Fragmented Policy and Institutional Frameworks: Inconsistent or poorly coordinated environmental policies across different government agencies can create confusion and regulatory uncertainty. A lack of clear institutional support and enforcement mechanisms can undermine efforts to implement AGSCM systematically.

- **Supply Chain Complexity and Lack of Transparency:** Agricultural supply chains are often long, fragmented, and involve numerous intermediaries, making it challenging to monitor and verify green practices across all stages. A lack of transparency can hinder the identification of sustainability risks and the effective implementation of green initiatives.
- **Market Imperfections and Price Sensitivity:** While consumer demand for green products is growing, a significant portion of the market remains price-sensitive. Consumers may not always be willing to pay a premium for sustainably produced goods, which can erode the economic incentive for firms to invest in AGSCM.

### 4.3. Green Practices Across the Agricultural Supply Chain

Our synthesis highlights a diverse array of green practices implemented at various stages of the agricultural supply chain, reflecting a holistic approach to environmental stewardship:

- **Green Procurement (Upstream):** This involves sourcing inputs (seeds, fertilizers, pesticides, packaging materials) from environmentally responsible suppliers. Practices include:
    - **Sustainable Sourcing:** Prioritizing suppliers who adhere to environmental standards, fair labor practices, and have certifications (e.g., organic, Rainforest Alliance, GlobalGAP).
    - **Reduced Input Use:** Implementing precision agriculture technologies (e.g., GPS-guided machinery, variable-rate application of fertilizers/pesticides) to minimize the use of water, energy, and chemicals, reducing runoff and emissions.
    - **Eco-friendly Inputs:** Using organic fertilizers, bio-pesticides, and disease-resistant crop varieties to reduce reliance on synthetic chemicals.
- **Eco-friendly Production (Farm Level):** These practices focus on minimizing the environmental footprint of farming operations:
    - **Conservation Agriculture:** Practices like no-till farming, cover cropping, and crop rotation to improve soil health, reduce erosion, and enhance carbon sequestration.
    - **Efficient Water Management:** Implementing drip irrigation, rainwater harvesting, and soil moisture sensors to optimize water use.
    - **Renewable Energy Adoption:** Utilizing solar panels, wind turbines, or bio-digesters for on-farm energy needs, reducing reliance on fossil fuels.
    - **Integrated Pest Management (IPM):** Employing biological controls, resistant varieties, and monitoring to minimize pesticide use.
- **Green Logistics and Distribution (Midstream):** Focuses on reducing the environmental impact of transportation and storage:
    - **Optimized Transportation Routes:** Using route optimization software to minimize travel distances, fuel consumption, and emissions.
    - **Efficient Cold Chain Management:** Implementing energy-efficient refrigeration technologies and optimizing cold storage facilities to reduce energy consumption and food spoilage.
    - **Modal Shift:** Shifting from road transport to more environmentally friendly modes like rail or waterways where feasible.

    - Fleet Modernization: Investing in more fuel-efficient vehicles or transitioning to electric/hybrid fleets.

- Sustainable Packaging: Designing and utilizing packaging that minimizes environmental impact:
    - Reduced Material Use: Using lightweight packaging, right-sizing packaging to minimize void space.
    - Recyclable, Reusable, and Biodegradable Materials: Prioritizing materials like recycled plastics, compostable bioplastics, or reusable crates.
    - Minimalist Design: Eliminating unnecessary packaging layers.
- Waste Management and Reverse Logistics (Downstream): Addressing waste generation and enabling circularity:
    - Food Waste Reduction: Implementing strategies to minimize post-harvest losses and food waste at all stages, from farm to consumer.
    - Composting and Anaerobic Digestion: Converting agricultural waste (crop residues, animal manure) into compost or biogas for energy generation.
    - By-product Utilization: Finding value-added uses for agricultural by-products (e.g., transforming fruit peels into ingredients).
    - Reverse Logistics for Packaging: Implementing systems for collecting and reusing or recycling packaging materials.
    - Product End-of-Life Management: Considering the disposal or recycling of agricultural inputs (e.g., fertilizer bags, pesticide containers).

### 4.4. Sustainability Performance Outcomes of AGSCM

The successful implementation of AGSCM practices yields multi-faceted benefits across environmental, economic, and social dimensions, aligning with the triple bottom line framework:

- Environmental Performance:
    - Reduced Greenhouse Gas Emissions: Lowering carbon footprints through optimized energy use, reduced reliance on synthetic inputs, and improved waste management (e.g., methane capture from manure).
    - Enhanced Biodiversity and Ecosystem Health: Promoting sustainable farming practices that protect natural habitats, soil health, and water quality, leading to healthier ecosystems.
    - Water Conservation: Implementing efficient irrigation techniques and reducing water pollution from agricultural runoff.
    - Waste Minimization: Significant reduction in agricultural waste (crop residues, food waste) and packaging waste through prevention, reuse, and recycling initiatives.
    - Reduced Chemical Pollution: Lowering the use of synthetic fertilizers and pesticides, mitigating their adverse impacts on soil, water, and human health.
- Economic Performance:

- **Cost Savings:** Long-term reduction in operational costs through increased resource efficiency (e.g., less water, energy, and chemical inputs), waste valorization, and optimized logistics.
- **Market Differentiation and Premium Pricing:** Gaining a competitive edge by appealing to eco-conscious consumers and accessing premium markets for certified sustainable products.
- **Enhanced Brand Reputation and Customer Loyalty:** Building a positive brand image and fostering stronger customer relationships through transparent and responsible practices.
- **Risk Mitigation:** Reducing exposure to environmental regulations, supply chain disruptions (e.g., climate change impacts), and reputational damage.
- **Improved Access to Finance:** Attracting green investors and securing favorable loan terms from financial institutions that prioritize sustainable businesses.
- **Operational Efficiency:** Streamlined processes and optimized resource allocation often lead to improved overall operational efficiency and productivity.

- Social Performance:
  - **Improved Livelihoods for Farmers:** Fairer trade practices, stable demand for sustainable products, and access to new markets can enhance farmers' income and economic stability.
  - **Enhanced Working Conditions:** Safer practices, reduced exposure to harmful chemicals, and fair labor standards contribute to better working environments for agricultural workers.
  - **Community Well-being:** Reduced environmental pollution benefits local communities, improving public health and quality of life.
  - **Food Security and Safety:** Sustainable practices contribute to long-term food security by preserving natural resources and reducing reliance on external inputs. Enhanced traceability through AGSCM also improves food safety.
  - **Increased Stakeholder Engagement:** Fostering better relationships with local communities, NGOs, and government bodies, leading to shared value creation.

### 4.5. Emerging Research Trends and Future Directions

The bibliometric analysis, particularly the keyword co-occurrence network in VOSviewer, reveals several dynamic research clusters and emerging frontiers within the AGSCM domain. These trends underscore the evolving complexity and interdisciplinary nature of the field:

- **Integration of Digital Technologies (Industry 4.0 and AGSCM):** A prominent cluster revolves around the application of transformative technologies such as the Internet of Things (IoT), blockchain, Big Data Analytics, and Artificial Intelligence (AI). Future research needs to deeply explore:
  - **Blockchain for Traceability and Transparency:** How blockchain can enhance supply chain visibility, ensure product authenticity, verify sustainability claims (e.g., organic certification, carbon footprint), and facilitate trust among AGSCM partners.

    - IoT and AI for Precision and Optimization: The role of IoT sensors in real-time monitoring of environmental conditions (soil moisture, nutrient levels, air quality), crop health, and logistics. AI can then leverage this big data for predictive analytics, optimizing resource use, predicting yields, and enabling dynamic routing.
    - Digital Platforms for Stakeholder Collaboration: How digital platforms can facilitate information exchange, foster collaboration among farmers, processors, retailers, and consumers, and streamline sustainable certification processes.
- Circular Economy (CE) Integration in Agribusiness: The shift from a linear "take-make-dispose" model to a circular one is gaining significant traction. Future research should investigate:
    - Waste Valorization and By-product Utilization: Exploring innovative technologies and business models for converting agricultural waste (e.g., crop residues, manure, food processing by-products) into value-added products (e.g., bio-fertilizers, bioenergy, animal feed, bio-plastics).
    - Reverse Logistics and Closed-Loop Systems: Designing efficient reverse logistics networks for agricultural packaging, unconsumed food products, and agricultural machinery components to facilitate reuse, recycling, or remanufacturing.
    - Ecosystem Services and Regenerative Agriculture: Quantifying the economic and environmental benefits of regenerative practices (e.g., enhanced soil carbon sequestration, improved water retention) within a circular economy framework.
- Performance Measurement and Impact Assessment: There is a growing need for robust and standardized metrics to assess the true impact of AGSCM initiatives. Future research could focus on:
    - Holistic Sustainability Metrics: Developing comprehensive frameworks that integrate environmental, economic, and social indicators beyond traditional financial metrics.
    - Life Cycle Assessment (LCA) and Carbon Footprinting: Conducting more granular LCAs for various agricultural products and supply chains to identify hot spots for environmental impact and inform targeted interventions.
    - Socio-Economic Impact Assessment: Quantifying the social benefits of AGSCM, such as poverty reduction, improved health outcomes, and gender empowerment in agricultural communities.
- Supply Chain Resilience and Climate Change Adaptation: As climate change intensifies, the intersection of AGSCM and supply chain resilience becomes critical. Research opportunities include:
    - Climate-Resilient Supply Chain Design: Investigating strategies for designing AGSCM networks that can withstand climate shocks (e.g., droughts, floods, extreme weather events) through diversification, localized sourcing, and adaptive capacity.
    - Risk Management in Green Supply Chains: Developing robust risk assessment and mitigation strategies specifically for green agricultural supply chains, considering both environmental and operational risks.
    - Role of Biodiversity in Resilience: Exploring how biodiversity conservation and agroecological practices contribute to the resilience of agricultural systems against pests, diseases, and climate variability.

- Policy and Governance Mechanisms: Effective AGSCM implementation requires supportive policy environments. Future studies should analyze:
    - Effectiveness of Green Policies: Evaluating the impact of different policy instruments (e.g., subsidies, carbon taxes, certification schemes) on AGSCM adoption and performance in various contexts.
    - Multi-Stakeholder Governance: Investigating how collaborative governance models involving governments, private sector, NGOs, and farmer organizations can accelerate AGSCM.
    - International Cooperation and Trade Agreements: Analyzing the role of international trade policies and agreements in promoting or hindering sustainable agricultural practices across global supply chains.
- Smallholder Inclusion and Capacity Building: A critical gap remains in understanding AGSCM from the perspective of smallholder farmers, who constitute a large segment of the global agricultural workforce. Research should address:
    - Business Models for Smallholder AGSCM: Developing viable business models that enable smallholders to adopt green practices and access green markets, overcoming financial and technological barriers.
    - Knowledge Transfer and Training Programs: Evaluating the effectiveness of extension services and capacity-building initiatives in disseminating AGSCM knowledge and skills to rural communities.
    - Digital Inclusion for Smallholders: Exploring how digital tools can be made accessible and beneficial for smallholder farmers to enhance their participation in green supply chains.

## 5. Conclusion

This comprehensive review reaffirms that Agricultural Green Supply Chain Management (AGSCM) is not merely a theoretical construct but a practical and strategic response to the escalating challenges of environmental degradation, climate risk, and socio-economic inequities within the global agribusiness system. The implementation of AGSCM along the agricultural supply chain yields significant benefits in environmental performance, economic competitiveness, and social equity. It represents a paradigm shift from a linear, resource-extractive model to a more circular, regenerative, and responsible approach to food

Future research needs to expand its scope, particularly to low-income countries, to provide context-specific insights into AGSCM adoption and its impacts. Furthermore, a stronger emphasis on the social dimensions of sustainability—such as gender equality, fair labor practices, and community empowerment—is crucial to ensure that AGSCM initiatives contribute to inclusive and equitable development. Longitudinal studies are also needed to assess the long-term scalability and systemic effects of AGSCM practices. By addressing these research gaps, the academic community can provide more robust evidence and actionable recommendations for a truly sustainable global agri-food system.

## BIBLIOGRAPHY

Ahi, P., & Searcy, C. (2013). A comparative literature analysis of definitions for green and sustainable supply chain management. *Journal of Cleaner Production, 52*, 329–341.

Carter, C. R., & Rogers, D. S. (2008). A framework of sustainable supply chain management: Moving toward new theory. *International Journal of Physical Distribution & Logistics Management, 38*(5), 360–387.

Chiu, M. C., Low, M. Y. H., & Chua, R. S. (2021). A closed-loop supply chain system framework for agricultural waste management. *Resources, Conservation and Recycling, 164*, 105119.

Crippa, M., Solazzo, E., Guizzardi, D., Monforti-Ferrario, F., Tubiello, F. N., & Leip, A. (2021). Food systems are responsible for a third of global anthropogenic GHG emissions. *Nature Food, 2*(3), 198–209.

Dey, A., LaGuardia, P., & Srinivasan, M. (2020). Building sustainability in logistics operations: A research agenda. *Management Research Review, 43*(8), 941–962.

Do, Q. H., Lee, C. K. M., & Ho, W. (2019). A benchmarking model for sustainable manufacturing in the food supply chain: An integrated fuzzy AHP and fuzzy TOPSIS approach. *International Journal of Production Research, 57*(18), 5581–5597.

Du, Q., Liu, J., & Lai, X. (2020). Supplier selection and order allocation in sustainable agri-food supply chains. *Journal of Cleaner Production, 275*, 123097.

Elkington, J. (1998). *Cannibals with forks: The triple bottom line of 21st century business*. New Society Publishers.

Garnett, T., Appleby, M. C., Balmford, A., Bateman, I. J., Benton, T. G., Bloomer, P., ... & Godfray, H. C. J. (2013). Sustainable intensification in agriculture: Premises and policies. *Science, 341*(6141), 33–34.

Golicic, S. L., & Smith, C. D. (2013). A meta-analysis of environmentally sustainable supply chain management practices and firm performance. *Journal of Supply Chain Management, 49*(2), 78–95.

Han, Z., & Huo, B. (2020). The impact of green supply chain integration on firm performance.
*International Journal of Production Economics, 227*, 107672.

Jum'a, L., Akhtar, P., & Khan, Z. (2022). Strategic orientations and sustainable performance: The role of green dynamic capabilities. *Journal of Business Research, 139*, 1118–1130.

Kabir, G., Sadiq, R., & Tesfamariam, S. (2020). A review of multi-criteria decision-making methods for sustainable supply chain management. *Sustainable Production and Consumption, 23*, 95–113.

Kaur, H., & Singh, S. P. (2018). Managing supply chains for sustainable operations in the food industry. *International Journal of Production Economics, 203*, 96–104.

Kumar, A., Mangla, S. K., Luthra, S., & Rana, N. P. (2021). Risk mitigation for sustainable supply chain: A framework integrating blockchain with DEMATEL-ISM-MICMAC approach. *Journal of Cleaner Production, 288*, 125582.

Mani, V., Gunasekaran, A., & Delgado, C. (2018). Enhancing supply chain performance through supplier social sustainability: An emerging economy perspective. *International Journal of Production Economics, 195*, 259–272.

Nelson, V., & Pound, B. (2009). *The last ten years: A comprehensive review of the literature on the impact of Fairtrade*. Natural Resources Institute, University of Greenwich. Porter, M. E., & Kramer, M. R. (2011). Creating shared value.

*Harvard Business Review, 89*(1/2), 62–77. Raut, R. D., Narkhede, B., & Gardas, B. B. (2019). To identify the critical success factors of sustainable supply chain management practices in the context of oil and gas industries: ISM approach. *Renewable and Sustainable Energy Reviews, 50*, 304–316.

Rezaei, J., Hemmes, A., & Tavasszy, L. (2018). Multimodal freight transport planning: A literature review. *European Journal of Operational Research, 274*(1), 1–15.

Sharma, M., Luthra, S., Joshi, S., & Kumar, A. (2017). Developing a framework for enhancing survivability of sustainable supply chains during and post-COVID-19 pandemic. *International Journal of Logistics Research and Applications, 20*(1), 1–19.

Singh, R. K., & Trivedi, A. (2019). An empirical analysis of supply chain risk and resilience practices in manufacturing industry. *International Journal of Quality & Reliability Management, 36*(8), 1389–1407.

Srivastava, S. K. (2007). Green supply-chain management: A state-of-the-art literature review.

*International Journal of Management Reviews, 9*(1), 53–80. Verghese, K., Lewis, H., & Fitzpatrick, L. (2015).

*Packaging for sustainability*. Springer.

Wang, Y., & Zhang, D. (2022). Green innovation and sustainable supply chain management: A study of Chinese agri-business firms. *Journal of Cleaner Production, 332*, 130026.

Yu, W., Chavez, R., Feng, M., & Wiengarten, F. (2021). Integrated green supply chain management and firm performance: The mediating role of social capital accumulation. I*nternational Journal of Production Economics, 140*(1), 8–19.

Zaid, A. A., Jaaron, A. A. M., & Bon, A. T. (2018). The impact of green supply chain management practices on sustainability performance: Evidence from manufacturing companies in Jordan. *Journal of Manufacturing Technology Management, 29*(4), 767–793.

Zhang, Y., & Huo, B. (2020). The impact of organizational culture on green supply chain integration and performance. *Industrial Marketing Management, 88*, 1–13.

Zhu, Q., & Sarkis, J. (2013). Green supply chain management: A literature review and future research directions. *International Journal of Production Research, 51*(10), 2869–2880.