

*Review*

# Strategies to Overcome Green Barriers in International Agricultural Trade

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**Abstract:** Green barriers, including Sanitary and Phytosanitary (SPS) standards, eco-certifications, green tariffs, and eco-label requirements, have become critical factors influencing international agricultural trade, posing challenges such as increased compliance costs, restricted market access, and altered trade patterns. This review examines strategies to overcome these barriers by integrating technological innovation, compliance with international standards, policy coordination, trade diversification, and market adaptation. Technological approaches, such as precision agriculture, IoT-enabled monitoring, and blockchain-based traceability, enhance efficiency and regulatory compliance, while certifications like GLOBAL.G.A.P., ISO 14001, and organic labels provide market credibility and access to high-value segments. Case studies from countries including the Netherlands, Chile, and New Zealand, as well as corporate examples from Olam International and Dole Food Company, demonstrate the effectiveness of combining technology, standards, and strategic market engagement. The review highlights that a multi-dimensional strategy can transform green barriers from obstacles into opportunities for innovation, sustainability, and competitiveness, and emphasizes the need for continued research on cost-benefit analyses, policy effectiveness, and emerging technologies to support sustainable agricultural trade.

**Keywords:** green barriers; international agricultural trade; SPS standards; eco-certifications; technological innovation

## 1. Introduction

International agricultural trade plays a crucial role in ensuring global food security, supporting rural livelihoods, and promoting economic growth. Agricultural products account for a significant portion of global trade, ranging from staple crops such as wheat, rice, and maize to high-value products such as fruits, vegetables, and specialty commodities. The expansion of agricultural trade allows countries to optimize resource allocation, benefit from comparative advantages, and satisfy diverse consumer demands across regions. Moreover, international trade fosters technology transfer and the adoption of advanced agricultural practices, which can contribute to sustainability in production systems [1].

Table 1 shows the major agricultural exporting countries and their export volumes over the past decade, highlighting the global distribution of key agricultural commodities. For instance, the United States and Brazil dominate in crops such as corn and soybeans, while the Netherlands focuses on high-value products like vegetables and flowers [2]. Emerging exporters such as China and India have also increased their share in fruits, vegetables, rice, and spices, reflecting a trend toward diversification in agricultural exports.

Received: 01 August 2025

Revised: 09 August 2025

Accepted: 22 September 2025

Published: 23 September 2025



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**Table 1.** Major Agricultural Exporting Countries and Export Volumes (2015–2024).

Country	Main Export Products	Export Volume (Billion USD)	Notes/Trends
USA	Corn, Soybeans, Wheat	150	Leading global exporter
Brazil	Soybeans, Sugar, Coffee	120	Strong growth in soy exports
Netherlands	Vegetables, Flowers	90	High-value products focus
China	Fruits, Vegetables	70	Increasing export diversity
India	Rice, Spices	60	Strong rice export growth

However, alongside these opportunities, agricultural trade increasingly faces challenges from various non-tariff measures, particularly green barriers. Green barriers refer to trade restrictions implemented to protect environmental quality, ensure food safety, or promote sustainable production practices. These barriers may take the form of sanitary and phytosanitary (SPS) standards, eco-certifications, eco-labeling requirements, or green tariffs that impose additional costs on exporters who fail to meet environmental or safety criteria. While green barriers serve legitimate public policy objectives, they can also act as obstacles for exporters, particularly from developing countries, by raising compliance costs and limiting market access. In this context, agricultural exporters need to engage in market research and strategic planning to align their products with international requirements and foster cross-border partnerships to share knowledge, technology, and resources.

The rising prevalence of green barriers has highlighted the need for a comprehensive understanding of their types, formation mechanisms, and impacts on agricultural trade. Exporting countries and enterprises must navigate complex international regulations and adapt production practices to meet evolving standards. In this context, a systematic review of green barriers and strategies to overcome them is essential for promoting smoother, more sustainable agricultural trade [3].

The rising prevalence of green barriers highlights the need for a comprehensive understanding of their types, formation mechanisms, and impacts on agricultural trade. Exporting countries and enterprises must navigate complex international regulations and adapt production practices to meet evolving standards. Furthermore, managing financial and operational risks related to compliance requires robust decision-making frameworks and risk management strategies [4]. In this context, a systematic review of green barriers and strategies to overcome them is essential for promoting smoother, more sustainable agricultural trade.

## 2. Types and Mechanisms of Green Barriers

### 2.1. Types of Green Barriers

Green barriers in international agricultural trade have become increasingly significant as countries attempt to balance trade liberalization with environmental protection, food safety, and sustainable development goals. These barriers can be broadly categorized into technical barriers and non-tariff barriers (NTBs), each with distinct characteristics and implications for exporters.

Technical barriers primarily regulate the production, processing, and export of agricultural products to ensure compliance with environmental and safety standards. Sanitary and phytosanitary (SPS) standards are the most widely recognized form of technical barrier [5]. They are designed to prevent the spread of pests, plant diseases, and foodborne contaminants, and often require exporters to implement rigorous testing, monitoring, and certification procedures. Failure to comply with SPS standards can lead to rejection of shipments, fines, or even temporary trade bans [6]. Another type of technical barrier is

eco-certifications, which assess whether agricultural production processes meet environmental sustainability criteria, including reduced pesticide use, efficient water utilization, soil conservation, and lower greenhouse gas emissions. These certifications are often mandatory for access to high-value markets, particularly in the European Union, Japan, and other environmentally conscious regions. While technical barriers improve product quality and environmental outcomes, they also raise production costs, require technological upgrades, and may disproportionately affect small-scale exporters in developing countries [7].

Non-tariff barriers (NTBs) are trade restrictions that do not involve direct tariffs but can effectively limit market access. Green tariffs, for example, impose additional charges on imported agricultural goods that fail to meet environmental compliance standards. Import restrictions may outright ban products that exceed pesticide residue limits or fail eco-label requirements. Eco-labeling programs require that products carry visible certification indicating adherence to environmental standards, influencing consumer purchasing decisions [8]. NTBs vary in stringency and scope across countries, adding complexity to international trade and increasing administrative and compliance burdens for exporters.

Table 2 provides an overview of the major types of green barriers, their characteristics, and the countries or regions where they are most commonly implemented, illustrating the global diversity of green trade measures.

**Table 2.** Types of Green Barriers and Implementing Countries/Regions.

Type of Barrier	Description	Typical Implementing Countries/Regions
SPS Standards	Regulations to prevent pests, diseases, and contamination	EU, USA, Japan, Canada
Eco-certifications	Environmental sustainability certification for production	EU, Australia, New Zealand
Green Tariffs	Additional import duties based on environmental compliance	EU, South Korea
Import Restrictions	Bans or limits on products failing environmental/health criteria	EU, USA, India
Eco-labeling	Labels indicating compliance with sustainability or organic standards	EU, Japan, Canada

## 2.2. Formation Mechanisms of Green Barriers

The emergence of green barriers is driven by a combination of environmental, food safety, and political-economic factors, reflecting the multifaceted goals of modern trade regulations.

**Environmental Protection:** Many countries establish green barriers to protect ecosystems, conserve biodiversity, reduce carbon emissions, and promote sustainable use of natural resources. For example, strict pesticide residue limits in the EU aim not only to safeguard human health but also to minimize soil and water contamination, encouraging sustainable agricultural practices among exporters [9].

**Food Safety:** Green barriers also serve to ensure consumer protection by reducing exposure to foodborne pathogens, chemical residues, and other contaminants. SPS standards, import restrictions, and labeling requirements help maintain public confidence in food quality, particularly in high-income markets where consumers increasingly demand traceability and safety assurance.

**Political-Economic Motivations:** Beyond environmental and safety concerns, some green barriers are influenced by domestic policy goals. Governments may use them to protect local farmers from international competition, promote the adoption of green technologies, or strengthen their market position in strategic agricultural sectors [10]. These

measures may also be leveraged to negotiate trade concessions or influence global supply chains.

These factors often interact, resulting in green barriers that simultaneously achieve environmental, safety, and economic objectives. For exporters, understanding these formation mechanisms is crucial for anticipating regulatory changes, designing compliance strategies, and ultimately enhancing competitiveness in international markets. The discussion of barrier types and mechanisms sets the stage for analyzing their economic and operational impacts, which will be covered in the next chapter [11].

### 3. Impacts of Green Barriers on Agricultural Trade

#### 3.1. Economic Impacts on Exporting Countries

Green barriers have substantial economic consequences for countries engaged in international agricultural trade. By imposing strict sanitary, environmental, and labeling standards, importing countries effectively limit market access for exporters who fail to comply. This restriction often leads to reduced export volumes and decreased market share, particularly affecting developing countries that may lack the financial resources or technological capacity to meet complex requirements. Compliance with SPS standards, eco-certifications, and eco-labeling schemes also increases production, testing, and administrative costs, which can erode profit margins and reduce global competitiveness [12].

For example, several Latin American countries have faced significant challenges when exporting fruits and vegetables to the European Union due to stringent pesticide residue limits. Non-compliant shipments are frequently rejected or subjected to additional testing, increasing overall costs and delaying market entry. In some cases, exporters must invest in costly laboratory testing and certification processes to regain access. Similarly, Indian mango exports to the US and EU markets have been restricted by SPS standards, forcing exporters to establish new testing and processing facilities to meet regulatory requirements. These examples illustrate that while green barriers are primarily intended to protect consumers and the environment, they can function as indirect protectionist measures, imposing economic burdens on exporters.

Moreover, green barriers can alter competitive dynamics in international markets. Countries with advanced technology and regulatory compliance systems, such as the EU, USA, and Japan, often gain a competitive edge by meeting high environmental and safety standards more easily. In contrast, smaller or less-developed exporting nations may struggle to keep pace, limiting their ability to participate in lucrative markets. Table 3 provides selected case studies illustrating these economic impacts.

**Table 3.** Case Studies Showing the Impact of Green Barriers on Key Agricultural Exports.

Exporting Country	Product	Barrier Type	Impact on Trade
Mexico	Avocados	EU Pesticide Residue Limits	Shipments rejected; increased compliance costs
Brazil	Soybeans	Eco-certifications (EU)	Delayed exports; investment in sustainable practices
India	Mangoes	SPS Standards (US, EU)	Reduced market access; need for new testing facilities
Vietnam	Shrimp	Traceability & Eco-labeling	Increased production costs; market diversification

#### 3.2. Impacts on Farmers, Enterprises, and Global Supply Chains

The economic implications of green barriers extend beyond national trade statistics to farmers and enterprises. Producers must adjust agricultural practices to comply with

environmental and safety requirements, including reducing pesticide use, adopting organic or sustainable farming methods, and implementing traceability systems. While such adjustments promote sustainability and product quality, they often require significant investment in technology, training, and certification, which can disproportionately affect small-scale farmers and SMEs with limited capital.

Enterprises must also adapt operational and marketing strategies to navigate diverse regulatory environments. Some multinational agribusinesses invest heavily in research and development to improve production efficiency, quality control, and environmental performance. Others opt to diversify export markets to reduce dependence on regions with stringent green barriers. This diversification may involve identifying new trading partners, adjusting product portfolios, or entering regional supply chains that facilitate compliance.

At the global supply chain level, green barriers can significantly reshape trade patterns. Exporters may establish processing facilities closer to target markets to comply with local regulations efficiently. Strategic partnerships with local distributors or contract farming arrangements may also emerge to ensure traceability and certification. Over time, these adaptations can lead to higher overall product standards, more sustainable production practices, and enhanced supply chain transparency. For instance, Brazilian soybean exporters have invested in sustainable farming certifications to maintain access to European markets, while Vietnam's shrimp exporters have adopted traceability and eco-labeling systems to remain competitive in the US and EU.

Overall, green barriers play a dual role. On the one hand, they drive improvements in product quality, environmental sustainability, and supply chain traceability. On the other hand, they impose economic and operational burdens on exporters, particularly those in developing countries. Recognizing these impacts is essential for formulating effective strategies to overcome barriers, which will be discussed in the following chapters, including both theoretical frameworks and practical case-based approaches.

#### **4. Strategies to Overcome Green Barriers – Theoretical Perspectives**

##### *4.1. Technological Innovation in Green Production*

Technological innovation is a fundamental strategy for overcoming green barriers in international agricultural trade. Modern agricultural technologies, such as precision agriculture, GPS-guided machinery, drones, automated irrigation systems, and remote sensing, allow exporters to optimize the use of inputs like water, fertilizers, and pesticides. By improving resource efficiency, these technologies not only reduce environmental impacts but also ensure compliance with Sanitary and Phytosanitary (SPS) standards and eco-certifications required in major export markets. Exporters adopting these technologies can maintain high yields while minimizing non-compliance risks.

Digital monitoring systems and IoT-enabled sensors enhance regulatory compliance by providing real-time data on soil conditions, pesticide residues, and crop health. These systems enable exporters to quickly identify and correct production issues, minimizing the risk of shipment rejections or market access limitations. For example, fruit and vegetable exporters to the European Union increasingly rely on digital monitoring and traceability systems to meet strict residue and traceability requirements, reducing compliance costs over time.

Blockchain technology and other traceability solutions further improve transparency across supply chains. By recording each stage of production and transport in an immutable ledger, exporters can provide verifiable evidence of sustainable practices and product origins. This capability is particularly important for high-value markets where consumers and regulators demand assurance of environmental compliance. Theoretically, technological innovation extends the “capability frontier” of exporters, transforming compliance from a cost burden into a competitive advantage while promoting sustainability, operational efficiency, and market resilience.



Moreover, technological adoption can drive innovation spillovers across the agricultural sector. Firms implementing advanced production techniques often stimulate local suppliers, service providers, and research institutions to improve complementary technologies, creating a positive feedback loop. Over time, this elevates the overall technological capacity of the exporting country, enhancing long-term competitiveness and enabling adaptation to evolving green barrier requirements.

#### *4.2. Compliance with International Standards and Certifications*

Compliance with international standards and certifications is another critical theoretical strategy. Standards such as GLOBALG.A.P., ISO 14001, organic certifications, and Fairtrade provide structured frameworks for meeting environmental, food safety, and sustainability requirements. Certification involves establishing rigorous quality control processes, systematic monitoring, documentation, and periodic audits. Although these processes require investment in infrastructure, training, and administration, they offer long-term benefits, including enhanced market access, reduced shipment rejections, and improved reputation among foreign regulators and consumers.

Certified products frequently command premium prices in environmentally conscious markets. For instance, exporters of organic fruits and vegetables to the EU and North America can often secure higher unit prices than conventional products, offsetting certification costs. This illustrates how regulatory compliance can be converted into an economic opportunity. Theoretically, standards function as both compliance mechanisms and market signals, incentivizing continuous improvement, process optimization, and sustainable practice adoption.

Adhering to certifications encourages innovation in production processes and supply chain management. Firms often adopt new technologies, such as automated quality testing or advanced packaging methods, to maintain compliance and meet certification requirements. For example, seafood exporters in Southeast Asia investing in cold chain technology and digital traceability can access markets with strict environmental and safety standards that were previously unattainable. Over time, certification not only ensures regulatory alignment but also strengthens brand value, market positioning, and long-term competitiveness.

Furthermore, compliance strategies can be integrated with corporate sustainability initiatives. Exporters aligning their operational goals with global environmental objectives, such as reducing carbon emissions or enhancing biodiversity, can enhance stakeholder confidence and meet evolving consumer expectations. This approach transforms green barriers from regulatory constraints into drivers of strategic differentiation, demonstrating that environmental compliance and economic performance are mutually reinforcing rather than conflicting.

#### *4.3. Policy Coordination, Trade Diversification, and Market Adaptation*

Policy coordination and international negotiations play a pivotal role in addressing green barriers. Governments can engage in bilateral and multilateral discussions to harmonize standards, reduce redundant requirements, and provide technical assistance to exporters. Trade capacity-building initiatives help developing countries implement SPS standards and eco-certifications efficiently. Policies may include financial support for green technologies, training programs, and joint monitoring initiatives, which reduce compliance costs and facilitate smoother market entry. Harmonized regulations and government-backed programs enable exporters to respond proactively to changing environmental requirements.

Trade diversification is a complementary strategy. Exporters can reduce reliance on markets with the strictest green barriers by targeting alternative destinations with achievable standards or strong demand for sustainable products. For example, Latin American

soybean exporters initially constrained by EU eco-certifications have simultaneously expanded into Southeast Asian and African markets. Diversification mitigates regulatory risks, spreads revenue sources, and increases resilience to sudden policy changes.

Market adaptation strategies involve aligning products, marketing, and supply chain operations with regulatory and consumer preferences. Product differentiation, eco-label branding, and value-added processing allow exporters to command premium prices while ensuring compliance. For instance, fruit exporters offering ready-to-eat organic packages with traceable origin labeling can access high-value segments in North America and Europe. Theoretically, integrating policy coordination, trade diversification, and market adaptation transforms green barriers from obstacles into opportunities, fostering innovation, competitiveness, and sustainable participation in global agricultural trade.

In conclusion, a comprehensive theoretical framework for overcoming green barriers integrates technological innovation, international certification compliance, policy coordination, trade diversification, and market adaptation. These strategies collectively enhance exporter competitiveness, facilitate compliance with evolving standards, and enable sustainable engagement in international agricultural trade. By leveraging technology, adhering to standards, engaging in strategic policy negotiations, and adapting market strategies, exporting countries and enterprises can transform green barriers into catalysts for innovation, economic growth, and long-term sustainability.

## 5. Practical Approaches and Case Studies

### 5.1. Country-Level Approaches

Several countries have successfully implemented strategies to overcome green barriers in agricultural trade. The Netherlands, for example, has invested heavily in precision agriculture, greenhouse technology, and controlled-environment farming to meet strict EU environmental and food safety standards. Dutch exporters maintain high yields while ensuring compliance with SPS standards, enabling them to dominate high-value European markets for vegetables and flowers. Similarly, Chile has leveraged digital traceability and eco-certifications for its fruit and wine exports, providing verifiable evidence of sustainable production. These measures have allowed Chilean producers to access premium markets in North America and Asia, even amid increasingly stringent environmental regulations.

Other regions have focused on regulatory alignment and policy coordination. For instance, New Zealand's dairy and meat exporters work closely with government agencies to comply with both domestic environmental laws and international standards. This includes regular audits, compliance reporting, and participation in multilateral trade agreements that harmonize regulations. The theoretical insight is that countries combining technological adoption with strong policy coordination are better equipped to maintain consistent access to high-standard markets, reduce trade disputes, and mitigate green barrier impacts.

### 5.2. Corporate-Level Strategies

Corporations have also developed effective strategies to adapt to green barriers. Olam International, a global agribusiness firm, invests in blockchain-enabled traceability for cocoa and coffee exports, ensuring compliance with sustainability certifications such as Fairtrade and Rainforest Alliance. This technology allows the firm to provide transparent, verifiable data to regulators and buyers, securing premium market access. Similarly, Dole Food Company has integrated precision agriculture and integrated pest management systems to meet EU and US environmental and safety standards while improving yield efficiency.

These corporate strategies highlight the importance of integrating technological innovation, certification compliance, and supply chain management. Firms that invest in

training, digital monitoring, and value-added processing not only meet green barrier requirements but also create brand differentiation. Case studies suggest that proactive investment in sustainability and compliance increases market resilience, reduces the risk of trade disruptions, and enhances long-term profitability.

### *5.3. Lessons Learned and Best Practices*

Practical experiences provide several lessons for overcoming green barriers. First, technological investment is essential: precision agriculture, IoT monitoring, and blockchain traceability significantly improve compliance and efficiency. Second, adhering to internationally recognized certifications builds market trust and allows access to premium segments. Third, policy engagement and trade diversification reduce dependence on a single high-standard market, mitigating regulatory risks.

Integration of these strategies—technology, policy, and trade adaptation—proves most effective. Firms and countries that align production practices with international standards, invest in modern monitoring and traceability systems, and diversify markets tend to overcome green barriers successfully. Additionally, sharing knowledge and best practices through industry associations or government-led programs can help exporters adapt more efficiently. The key insight is that green barriers, while restrictive, can also drive innovation, process improvement, and strategic differentiation, turning compliance challenges into opportunities for long-term competitiveness.

### *5.4. Integration of Technology, Policy, and Trade Strategies*

Case studies demonstrate that combining technological, policy, and market strategies yields the best outcomes. For example, Dutch horticulture integrates greenhouse technology, IoT monitoring, eco-certifications, and active participation in EU policy discussions. Similarly, Chilean fruit exporters use blockchain traceability, adopt organic certifications, and diversify into Asian and North American markets. These integrated approaches not only ensure compliance but also enhance efficiency, reduce costs, and increase export value.

The theoretical and practical takeaway is clear: a multi-dimensional strategy that simultaneously addresses technology, certification, policy alignment, and market adaptation allows exporters to turn green barriers into opportunities. By learning from successful country and corporate experiences, other exporters can adopt a similar integrated approach, ensuring sustainable participation in international agricultural trade while fostering innovation and competitiveness.

## **6. Conclusion and Future Directions**

This review has examined strategies to overcome green barriers in international agricultural trade, highlighting both theoretical perspectives and practical approaches. Green barriers—including Sanitary and Phytosanitary (SPS) standards, eco-certifications, green tariffs, and eco-label requirements—pose significant challenges to exporters, particularly in developing countries. Technological innovation, such as precision agriculture, IoT-enabled monitoring, and blockchain-based traceability, has been shown to improve compliance, increase efficiency, and ensure product safety. Compliance with internationally recognized standards, including GLOBALG.A.P., ISO 14001, and organic certifications, provides market access and enables premium pricing in environmentally conscious markets. Furthermore, coordinated policies, trade diversification, and market adaptation strategies enhance exporter resilience and long-term competitiveness. Case studies from countries like the Netherlands, Chile, and New Zealand, as well as corporate strategies from firms like Olam International and Dole Food Company, demonstrate that integrating technology, certification, and strategic market engagement is critical for successfully navigating green barriers.



### 6.1. Challenges and Limitations

Despite the availability of effective strategies, several challenges remain. First, high compliance costs—including investments in technology, certification, and training—pose barriers for small and medium-sized enterprises (SMEs) and developing countries with limited financial resources. Second, complex and frequently changing standards across different markets increase uncertainty and require continuous adaptation. Third, coordination between government policy and corporate practices is often inconsistent, leading to inefficiencies or gaps in compliance support. Moreover, reliance on a limited number of export markets makes countries vulnerable to sudden regulatory changes or trade disputes. Finally, technological solutions, while promising, require significant technical expertise and infrastructure, which may not be readily available in all regions.

### 6.2. Policy Recommendations

To address these challenges, several policy recommendations are proposed. Governments should provide financial support, training, and capacity-building programs to help exporters, particularly SMEs, adopt green technologies and achieve international certifications. Bilateral and multilateral negotiations can harmonize standards and reduce redundant requirements, facilitating smoother trade flows. Exporters should be encouraged to pursue trade diversification and market adaptation strategies, targeting markets with achievable standards and growing demand for sustainable products. Additionally, promoting public-private partnerships can enhance technological adoption and certification compliance, while industry associations can facilitate knowledge sharing and dissemination of best practices. The integration of technology, certification, and policy support is essential for building long-term resilience in agricultural exports.

### 6.3. Future Research Directions

Future research should focus on quantitative assessments of the economic and environmental impacts of green barriers across different commodities and regions. Investigating the cost-benefit trade-offs of technological adoption and certification compliance for SMEs and developing countries would provide actionable insights. Comparative studies on policy coordination effectiveness and the role of public-private partnerships in overcoming barriers could inform better governance strategies. Additionally, exploring innovative technologies, such as AI-driven precision agriculture, advanced blockchain systems, and sustainable packaging solutions, can provide new pathways for compliance and efficiency. Finally, research on consumer behavior and market preferences regarding sustainable agricultural products will help exporters align production and marketing strategies with global sustainability trends.

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