



Enhancing Sustainable Food Value Chain by Establishing Agricultural Cold Chain and Promoting Good Agricultural Practices

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ABSTRACT

Taiwan is in tropical and subtropical climate zones, fostering diverse and abundant agricultural products. However, most of these products are prone to damage and spoilage during storage and transportation, leading to losses and raising concerns about food safety. In response, the government has actively promoted the industry in recent years to establish a sustainable agricultural supply chain, which is defined as the physical system for moving products from farmers to consumers while focusing on logistical efficiency. In this article, two strategies to promote a sustainable food value chain—a strategic framework focused on creating value and increasing profitability at each stage of production and distribution—are listed. By implementing “Building an Agricultural Product Cold-chain Logistics and Quality Assurance System” and “Traceability Certification System”, a comprehensive temperature-controlled logistics system from production to consumption is being introduced, along with traceability and risk management concepts. These efforts not only effectively enhance product quality and safety, improve operational efficiency, develop modern, high-end distribution channels, and build domestic and international consumer trust in Taiwan’s agricultural products, but also introduce the concept of sustainability into the agricultural industry.

Keywords: agricultural cold chain, Traceability Certification System, Good Agricultural Practices, agricultural supply chain, food value chain, food safety, and risk management

INTRODUCTION

In the past, Taiwan’s agricultural product marketing focused on domestic traditional markets, where cold chain logistics and quality standards were often overlooked. Recently, rising food safety awareness and shifting lifestyles have transitioned the retail landscape toward modern channels, such as hypermarkets, supermarkets, and convenience stores. Furthermore, the COVID-19 pandemic has accelerated the expansion of e-commerce platforms, while government efforts to explore emerging international export markets have heightened demand for cold chain and long-distance transportation solutions. Consequently, maintaining postharvest quality, freshness, and shelf life while minimizing losses has become essential for value creation and profitability for producers, logistics providers, and retailers alike.

A retrospective analysis identifies several systemic bottlenecks:

- **Preharvest:** Improper pesticide and fertilizer management threaten product safety and sustainability.
- **Postharvest:** Inadequate precooling and delayed cooling cause moisture loss and spoilage in crops.
- **Sorting & packing:** Reliance on manual labor and a lack of standardized cold facilities lead to inefficiencies and inconsistent quality.
- **Storage:** Aging infrastructure and insufficient capacity during peak seasons cause detrimental temperature and humidity fluctuations.
- **Distribution:** Outdated refrigerated vehicles and the lack of real-time monitoring compromise quality during transit.

- **Retail:** A deficit in value-added processing (e.g., vacuum packaging, ready-to-eat products) limits competitiveness in high-end and e-commerce markets.

To address challenges, the government has initiated the "Building an Agricultural Product Cold-chain Logistics and Quality Assurance System" and the "Traceability Certification System." These efforts aim to integrate a cold chain system across the agricultural supply chain, constructing a modern logistics and agricultural product safety model. Taiwan government has established the Taiwan Good Agricultural Practices (TGAP), a set of guidelines designed to ensure the safety and quality of agricultural products. Through third-party certification—accredited by the Taiwan Accreditation Foundation (TAF) under the authorization of the Ministry of Agriculture (MOA)—and a robust support system, TGAP ensures compliance with global standards and addresses the rising demand for food safety and value-chain sustainability.

STRATEGY AND SUPPORT MEASURES

Building an agricultural product cold-chain logistics and quality assurance system

The promotion of cold-chain policies has become a global trend. Nearby ASEAN countries have also introduced the ASEAN Cold-chain Initiatives. Due to high temperatures and humidity in Southeast Asia, post-harvest loss rates for agricultural products are extremely high, with an estimated 90% of food waste occurring during transportation, creating an urgent need for modern cold-chain logistics.

Owing to uneven regional development, ASEAN nations are leveraging Public-Private Partnerships (PPP) and attracting foreign investment to build infrastructure. They are also actively seeking to sign MOUs with advanced countries to transform local enterprises. In contrast, Taiwan adopts a government-led approach, investing resources to establish demonstration sites that serve as models for other industries and attract private sector investment. This reduces the initial risk for the private sector and provides a clear blueprint for developing economies that may lack initial private investment in high-cost infrastructure.

To maximize the effectiveness of investments, key areas have been selected to introduce the cold chain system:

1) **Establishment of flagship logistics centers (export-oriented)**

Focusing on the export market, these centers offer "one-stop" services, integrating international transfer, packaging, processing, and streamlined customs/quarantine clearance.

2) **Building regional cold chain centers (production-based)**

Regional cold chain logistics centers have been constructed in key production areas. These centers incorporate smart management and distribution systems, and integrate functions such as grading, packaging, pre-cooling, refrigeration (freezing), or processing. The government also provides key indicators for operating units to assist in making comprehensive assessments, focusing on clarity and reasonableness of development direction, target market size and potential competitor analysis, setting of short, medium, and long-term goals, development of operational strategies and foresight, architectural planning, and benefit analysis, as well as investment risk management. Regional cold chain logistics centers leverage economies of scale to regulate market supply and demand and drive the development of local and surrounding industries.

3) **Upgrading quarantine facilities**

Taiwan is endemic to fruit flies such as the melon fly and the oriental fruit fly. Some fresh fruits exported to specific countries require quarantine treatment and must obtain the approval of the importing country before they can be sold abroad, such as mangoes exported to Japan and South Korea. However, strict quarantine treatment can lead to product losses. Outdated equipment has been replaced, and backup power systems have been installed to enhance processing efficiency and reduce product loss.

4) **Improving wholesale markets**

Improvements include electronic trading, real-name traceability, and cold chain equipment. A system of new folding baskets for cyclical reuse has also been implemented to replace the traditional cardboard packaging. Their perforated and foldable design helps preserve freshness and save storage space. This change reduces waste and maintains the integrity of the cold chain at the production end.

5) **Assisting producers in upgrading facilities**

The government encourages producers of high-potential or supply-sensitive crops to adopt energy-efficient and high-performance equipment. The goal is to transition toward large-scale, group-based, and sustainable operations while improving efficiency and reducing carbon emissions.

The implementation of cold-chain policies has faced several challenges, including a lack of professional expertise among participants, leading to inefficient use of facilities and equipment and resulting in inefficient capital allocation. Furthermore, consumers often lack an understanding of the critical role cold chains play in food safety. To address these issues, the government has invited experts to form an advisory team to provide consultation services, including site planning and equipment use. The government has also established learning courses and organized benchmark site visits to promote industry advancement. Additionally, the government conducts promotional marketing activities to help consumers understand how a cold chain system ensures the quality and food safety of agricultural products.

Establishing traceability certification system

Since 2007, Taiwan has established a robust regulatory framework for its Traceability Certification System and has continuously developed TGAP. Developed by experts, TGAP provides operational manuals based on Hazard Analysis and Critical Control Points (HACCP) and risk assessments. These guidelines ensure proper material use while integrating pesticide and food safety and environmental sustainability. Producers are required to record and upload their production data to a centralized information system. Recently, TGAP has incorporated sustainable farming concepts, including environmental checkups, rational fertilization, waste management, Integrated Pest Management (IPM), and personnel wellness.

Producers wishing to participate in the traceability certification system must strictly adhere to TGAP. Third-party certification bodies audit and verify that producers' practices, records, and actions align. Furthermore, the government incentivizes participation by providing environmental subsidies and offsetting certification fees, thereby encouraging producers to integrate into the traceability framework. Once a product passes third-party audits and inspections, it is eligible to display the Traceable Agricultural Product (TAP) logo, and the logo is permitted for use in sales. Consumers can use the QR code or traceability code on the packaging to access production details, ensuring transparency throughout the supply chain. Third-party verification prevents product adulteration and counterfeiting. In the event of a food safety violation, certified products can be quickly identified by batch numbers, ensuring that unaffected sales continue. If an issue arises with a certified product, it can be precisely traced for a targeted recall, minimizing costs for suppliers.

RESULTS

Since its 2021 launch, the cold chain policy has yielded significant results through smart and digital integration. The implementation of a full-process logistics system has reduced average product loss from 25% to 10%, thereby saving NT\$580 million. Additionally, the processing capacity for key items has grown from 850,000 to 1.21 million metric tons—a 42% increase—accounting for 12% of their total production volume. The average shelf life has been extended threefold, improving the flexibility of production and marketing scheduling during peak seasons.

In wholesale markets, the reusable folding basket system recorded over 3.08 million uses by April 2025, drastically reducing waste. Export quarantine improvements have also minimized losses: steam heat treatment damage dropped from 20–25% to 15% (e.g., mango and lychee), and cold damage fell from 15% to 5% (e.g., guava and pomelo), bolstering international competitiveness.

This structural transformation has facilitated entry into high-end markets and modern retail channels (convenience stores, supermarkets, and home delivery). Notably, pineapple exports successfully shifted from Mainland China to Japan, with annual volumes surging from 2,000 to approximately 20,000 metric tons, meeting Japan's stringent quality standards.

Since 2007, the government has supported the Traceability Certification System through subsidies for certification, inspections, digitalization personnel, and equipment. Certified producers also receive annual environmental subsidies and on-site assistance from trained experts.

To promote agricultural sustainability, the government launched TGAP PLUS in 2022, building upon the original framework by incorporating GLOBALG.A.P.'s Integrated Pest Management (IPM) principles.

In addition to increasing the requirements for the application of Integrated Crop Management (ICM) and Integrated Pest Management (IPM), this upgrade emphasizes the balance between four key areas: "Good Agricultural Practices," "Food Safety," "Labor Safety," and "Environmental Sustainability. TGAP PLUS provides agricultural product operators with guidelines that incorporate sustainability principles, enabling them to adopt

this advanced certification. Relevant advanced criteria are also gradually integrated into the general TGAP to help establish a sustainable food chain.

As of the end of April 2025, the area certified under agricultural traceability has reached 109,855 hectares, accounting for approximately 15% of the total cropland (723,668 hectares). This represents a nearly seven-fold increase from the 15,938 hectares recorded in 2018. The annual production volume has climbed to 1.2 million metric tons, with the production value reaching NT\$40.3 billion (US\$1.25 billion), reflecting rapid growth.

Table 1. A Comparative Analysis of GLOBALG.A.P., TGAP Plus, and TGAP

	TGAP	TGAP Plus	GLOBALG.A.P.
Core Focus	Safe and Traceable	Safety, Traceability, Integrated Pest Management (IPM) and Integrated Crop Management (ICM), while integrating the concepts of Environmental Sustainability, Social Wellbeing, and Worker Welfare to align with international standards	Safety, Traceability, Integrated Pest Management (IPM), Integrated Crop Management (ICM), Environmental Sustainability, Social Wellbeing, and Worker Welfare.
Statement of CPCC	Providing standardized operating procedures for farmers to follow	Providing standardized operating procedures for farmers to follow	Providing a principle-oriented system for risk management
Control Points and Compliance Criteria	Crop-specific	Crop-specific	Modular Design
Data Registration	Must be uploaded to the online platform for public inquiry	Must be uploaded to the online platform for public inquiry	Self-recording
Business Model	B to C	B to C	B to B
Logo Use	Can be displayed on the product	Can be displayed on the product	Label the GGN (GLOBALG.A.P. Number) for GLOBALG.A.P.-certified products, or the GLN (Global Location Number) for Local GAP-certified products.



Figure 1. Han Kuan Fruit & Vegetable Production Cooperative- Regional Cold Chain Logistics Center



Figure 2. A new folding basket recycling system (right) has been implemented to replace the traditional cardboard packaging (left), preventing cardboard collapse caused by moisture and reducing single-use waste



Figure 3. The core value of the TAP Traceability Certification System

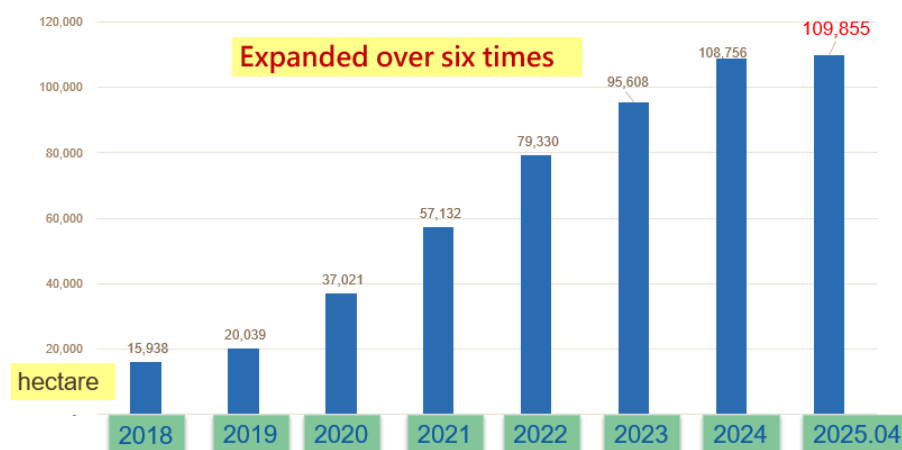


Figure 4. Trends in the TAP-certified area in Taiwan show significant expansion after several years of government investment and guidance.

CONCLUSION

In summary, Taiwan's dual approach—developing a comprehensive cold chain system and promoting sustainable practices—offers a transferable model for value-chain modernization. The Taiwan experience demonstrates that government–farmer collaboration, supported by a robust public investment model, is crucial for scaling up policy implementation. These experiences suggest that integrating traceability and cold chain systems into the supply chain not only enhances food security from farm to table but also enables small-scale farming to compete in high-end export markets, ultimately transforming agriculture into a highly competitive and reliable industry.

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AUTHORS' CONTRIBUTIONS

The co-authors collectively contributed to the completion of this article. Ya-Chin Lee collected information, conceived the study, and drafted the manuscript. Shu-Fen Tseng reviewed and revised the manuscript, providing critical feedback.

CONFLICT OF INTEREST

Ya-Chin Lee and Shu-Fen Tseng declare that they have no conflict of interests.