

From Climate Crisis and Challenges to Becoming a Food Security Hub in Northern Thailand

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Parichat Theanjumpol, Ph.D.; Nadthawat Noimanee, Ph.D.;
Yaowaluk Chanbang, Ph.D.; and Phuangphet Hemrattrakun, Ph.D.*

Abstract

Climate change, increasing climate variability, and extreme weather events are significantly affecting the production, quality, consistency of yields, and production costs of major economic crops in Northern Thailand, including rice, longan, maize, sugarcane, highland vegetables, Arabica coffee, tea, cassava, avocado, and macadamia. In response to increasing climate variability, stakeholders across the agricultural sector including producers, academic institutions, government agencies, and the private sector, have continuously strengthened their preparedness and adapted to these changing conditions through advances in technology, knowledge, and agricultural innovation. These efforts demonstrate the strong and rapidly evolving resilience of Northern Thailand's agricultural sector. The region's capacity to produce a diverse range of crops, together with its geographical diversity and strong agricultural production capabilities, helps mitigate the impacts of climate change and enables the region to maintain production levels of key agricultural commodities despite increasingly variable climatic conditions.

However, the increasing severity of climate change highlights the need to further advance technologies, production processes, innovations, and more efficient resource management, while strengthening the adaptive capacity of the agricultural production sector. These challenges therefore present an opportunity for Northern Thailand to enhance its resilience and preparedness for ongoing and future changes, while advancing toward becoming a "Food Security Hub of Northern Thailand." This transformation will be driven by advanced technologies, agricultural innovation, and enhanced capabilities and competitiveness in food security, strengthening the region's capacity to respond effectively to future climate-related challenges.

Global Crises and Food Security in a New Era

Climate change is no longer merely an environmental crisis; it has become one of the most serious geopolitical and economic threats to the global food system. The increasingly complex interactions and alternating patterns of El Niño and La Niña are contributing to extreme events that are becoming more difficult to anticipate and manage. Rising global average temperatures, highly variable and increasingly unpredictable rainfall patterns, and outbreaks of emerging crop pests affecting both preharvest and postharvest stages are causing severe declines in agricultural productivity across many of the world's major food-producing regions.

However, Northern Thailand, with more than 16 million rai of cultivated land devoted to major economic and high-value crops, possesses distinctive geographical characteristics ranging from lowland plains to highland areas. The region is also endowed with diverse ecosystems, rich biodiversity, and a strong research and development (R&D) capacity. These strengths provide Northern Thailand with considerable potential to transform current challenges into strategic opportunities and establish itself as an important source of food crops contributing to global food security through ten key crops.

Furthermore, the region has the capacity to rapidly adapt its agricultural production to meet changing international demand for essential food crops. Northern Thailand has a comprehensive agricultural production ecosystem that can effectively address multiple dimensions of food security, encompassing staple food crops, crops supporting livestock production and related industrial value chains, as well as high-value crops for nutritional and energy purposes, as detailed in Table 1.

Table 1. Potential, Adaptability, and Strategic Opportunities of Major Economic Crop in Northern Thailand

Economic crops	Production area/Economic value	Impact and Key Challenges	Positive Adaptation	Global Opportunity
1. Rice (Staple food crop)	Cultivated area: 2.24 million hectares; production volume: 3.5–4.0 million tones; economic value: 40 billion THB (Office of Agricultural Economics, 2023–2024).	Drought, flooding, and high temperatures are negatively affecting rice production in many countries, resulting in reduced yields and lower rice quality.	– Alternate Wetting and Drying (AWD) rice cultivation combined with advanced technologies to reduce greenhouse gas emissions – Laser Land Leveling (LLL) – Development of flood- and drought-tolerant rice varieties	Strengthening Thailand's role as a food security hub by enhancing resilience to climate change, supporting sustainable development and low-carbon production in alignment with global environmental measures, while creating opportunities to develop innovative products that meet the evolving needs of consumers worldwide.
2. Longan (High-Value Export Crop)	Cultivated area: 160,000–192,000 hectares; production volume: 0.9 million tones; economic value: 35–45 billion THB (Office of Agricultural Economics, 2025).	Higher temperatures result in irregular flowering, while rainfall increases fruit cracking and disease incidence.	– Use of drone technology to monitor and predict plant health and enhance adaptation to changing climatic conditions. – Use of smart sprinkler and misting systems to reduce canopy temperature in response to changing climatic conditions. – Development of novel products using bioactive compounds extracted from longan peel and seeds to meet consumer demand for high-quality foods.	Longan is an energy-rich fruit with potential to serve as a food source for consumers in colder regions and Arab markets. Its value can be further enhanced through the development of value-added products for the functional food and superfood industries, with an emphasis on low-carbon production and energy-rich food products. Longan and its bioactive compounds also have potential for the development of high-value cosmeceutical products in response to growing global market demand. Market development should focus on upgrading conventional fresh longan to premium products for modern trade and e-commerce markets, while expanding exports of ready-to-eat processed longan and longan extracts for pharmaceutical formulations and dietary supplements. These target markets have relatively high purchasing power and demand for sweet tropical fruits. Thailand therefore has opportunities to export premium-grade fresh longan via air freight, as well as Halal-certified, superfood-grade freeze-dried longan, thereby creating new market opportunities and strengthening the future competitiveness of Thailand's longan industry.

Economic crops	Production area/Economic value	Impact and Key Challenges	Positive Adaptation	Global Opportunity
3. Maize (Livestock Feed Crop)	Cultivated area: 640,000–800,000 hectares; production volume: 3 million tones; economic value: 38 billion THB (Office of Agricultural Economics, 2025)	Drought during the flowering stage, soil erosion on sloping land, and PM2.5 pollution caused by open burning in maize production areas.	– Development of drought-tolerant hybrid maize varieties for cultivation after rice harvesting – Development of high-yielding, high-quality maize varieties using agricultural biotechnology – Conversion of maize cobs and stalks into biochar for soil improvement and carbon sequestration – Development of environmentally friendly production processes	Positioning Thailand as a “Regional and Global Hub for Protein Security and Low-Carbon Livestock Feed Resources.” With its strong production capacity, technological development, and ability to respond to industry demand, Thailand has the potential to strengthen the security and resilience of feed and livestock-input supply chains. Promoting burn-free production practices can help reduce pollution and advance green agriculture, while meeting the growing demand of both domestic and international industries. Furthermore, the adoption of agroforestry, regenerative agriculture, and crop rotation systems within the animal feed industry can contribute to more sustainable and resilient agricultural production systems.

Economic crops	Production area/Economic value	Impact and Key Challenges	Positive Adaptation	Global Opportunity
4. Sugarcane (Industrial & Energy Crop)	Cultivated area: 320,000 hectares; production volume: 20 million tones; economic value: 20 billion THB (Office of the Cane and Sugar Board, 2025)	– Declining agricultural labor availability due to border-related issues – Drought conditions reduce sugar content and cane weight – Environmental challenges associated with illegal burning in sugarcane fields	– GPS-guided auto-steer harvesters for green sugarcane harvesting – The “Check Phao” application for real-time satellite monitoring of agricultural burning – Utilization of agricultural biomass for renewable energy production – Advanced agricultural technologies to enhance production capacity and ensure that agricultural produce meets industry standards and quality requirements through effective quality assurance (QA) and quality control (QC) systems	Positioning Northern Thailand as a sustainable production base and key supplier for the sugar industry, with the capacity to continuously adapt to climate change through advanced production and processing technologies and innovations, including the development of a regional biorefinery industry. This will enable the region to sustainably meet the needs of the private sector and consumers in both domestic and international markets. Sugarcane and its biomass can also serve as key feedstocks for future industries, including bioplastics, ethanol, sustainable aviation fuel (SAF), bio-based products, and biomass-based electricity generation.

Economic crops	Production area/Economic value	Impact and Key Challenges	Positive Adaptation	Global Opportunity
5. Highland Vegetables	Cultivated area: 56,000 hectares; production volume: 400,000 tones; economic value: 12 billion THB (Office of Agricultural Economics , 2025).	– Climate change increases the susceptibility of highland vegetables to heat stress. – Emergence of new diseases and insect pests during the rainy season. – Increasing postharvest losses.	– Use of smart greenhouse technologies powered by clean energy for crop production under changing climatic conditions – Development of energy-efficient cold chain systems – Application of advanced packaging technologies to extend shelf-life and maintain product quality – Application of advanced technologies and biological control methods for pest management, in compliance with GAP and organic production standards	Northern Thailand encompasses agricultural areas across a wide range of elevations, from lowland plains to mountainous highlands. This geographical diversity enables year-round production planning for both highland and tropical vegetables. When lowland production areas are affected by heat stress or flooding, upland and highland areas can serve as alternative production zones for high-quality vegetables, thereby strengthening the resilience and continuity of the regional food supply. Northern Thailand also has strong potential for the rapid production and distribution of agricultural products to both domestic and international markets, supported by continuously improving logistics infrastructure. In addition, academic institutions, highland development organizations including the Royal Project Foundation and the Highland Research and Development Institute (HRDI) as well as various government agencies provide technical support and other forms of assistance to help farmers adapt to climate change. The region is further supported by transportation networks connecting land and air transport, as well as relevant water-based transport systems. These strengths provide an opportunity to position Northern Thailand as a regional hub for food security and the supply of safe, high-quality food crops. Modern food security is no longer concerned solely with providing sufficient staple foods and carbohydrates; it increasingly emphasizes access to fresh vegetables that provide essential vitamins, minerals, antioxidants, and other health-promoting compounds. Northern Thailand's vegetable sector is therefore well positioned to meet the needs of health- and wellness-oriented consumers and aging societies, while creating opportunities for the development of high-value food products, functional foods, and future foods, including emerging crops and food resources such as Wolffia (phak pham) and kale.

Economic crops	Production area/Economic value	Impact and Key Challenges	Positive Adaptation	Global Opportunity
6. Arabica coffee	Cultivated area: 16,000 hectares; production volume: 10,000 tones; economic value: 1.8 billion THB (Office of Agricultural Economics, 2025).	– Rising temperatures are making some production areas less suitable for Arabica coffee cultivation. – Increasing outbreaks of diseases and insect pests pose greater risks and cause more severe crop damage. – Climate variability increases the risk of freezing injury. – Coffee yields are declining due to changing climatic conditions.	– Development of advanced agroforestry systems for shade-grown coffee integrated with smart agricultural technologies – Development of new coffee varieties adapted to changing climatic conditions – Development of coffee production and value-added processing through low-carbon anaerobic fermentation for specialty-grade coffee – Development of blockchain-based traceability systems to verify the geolocation of forest-friendly coffee farms in compliance with the EU Deforestation Regulation (EUDR)	Northern Thailand has strong potential to adapt to climate change through intensive and sustainable farming practices, supported by close collaboration between local farmer groups and academic experts to develop appropriate coffee production systems under global warming conditions. The region also has the potential to become a leader in the development and production of premium specialty coffee that meets internationally recognized environmental standards and complies with emerging global trade requirements. Furthermore, Northern Thailand can be developed as a Coffee Knowledge and Tourism Hub, integrating coffee production, research, innovation, local communities, and coffee tourism. Thai coffee can be strategically positioned in the global market as “Forest-Friendly Specialty Coffee”, supported by compliance and certification schemes such as EUDR, Organic, and Geographical Indication (GI) standards. Free Trade Agreements (FTAs) can also be leveraged to expand access to international markets, following a quality-driven rather than volume-driven strategy.

Economic crops	Production area/Economic value	Impact and Key Challenges	Positive Adaptation	Global Opportunity
7. Tea (Water Resource Conservation Crop)	Cultivated area: 20,800 hectares; production volume: 100,000 tones; economic value: 1.2 billion THB (Highland Research and Development Institute, 2024).	High temperatures and drought reduce the quality of tea shoots, while the incidence of plant diseases increases.	– Integration of tea cultivation with perennial trees in agroforestry systems to conserve forests and headwater areas – Development and application of IoT technologies for monitoring changes in environmental conditions – Upgrading production standards and developing value-added processed tea products, supported by Geographical Indication (GI) certification	Thai tea has strong potential to serve the growing premium health and wellness beverage market, both domestically and internationally, while also strengthening low-carbon ecotourism. In particular, modern agricultural systems that integrate sustainable production with natural ecosystems can create synergy between environmental conservation, agricultural production, and high-value product development. Significant opportunities also exist in biorefinery and functional ingredient development through the extraction of high-value compounds, particularly epigallocatechin gallate (EGCG) and other antioxidants, from tea leaves and agricultural by-products such as mature leaves and tea stems. These bioactive compounds can be developed as key ingredients for dietary supplements, health beverages, functional foods, cosmeceuticals, and pharmaceutical products, thereby creating additional value from the entire tea production chain. Further opportunities include expansion into ready-to-drink (RTD) and specialty tea products, such as kombucha, cold-extracted tea powders, natural tea flavoring ingredients, and innovative tea blends incorporating distinctive Thai herbs, tropical fruits, and flowers—for example, longan-infused tea and Thai floral tea blends—targeting premium domestic and international markets.

Economic crops	Production area/Economic value	Impact and Key Challenges	Positive Adaptation	Global Opportunity
8. Casava	Cultivated area: 320,000 hectares; production volume: 7 million tones; economic value: 8.5 billion THB (Office of Agricultural Economics, 2025).	– Severe drought reduces starch accumulation and adversely affects cassava quality. – Increasing heat accumulation in production areas and rapidly changing climatic conditions require the development of more adaptive and appropriate production systems. – Increasing outbreaks of emerging diseases and insect pests, such as cassava mosaic disease (CMD).	– Use of drought-tolerant cassava planting materials and surveillance systems for emerging diseases – Development of climate-resilient production systems under changing climatic conditions – Application of advanced and integrated soil management technologies, including soil-enriching legumes and cover crops, to improve soil quality and reduce soil erosion – Application of AI and drone technologies to monitor, survey, and assess stress in cassava plants	Cassava is a climate-resilient carbohydrate crop with a high tolerance to drought, extreme heat, and degraded soil conditions. It can maintain relatively high productivity compared with many other crops under climate variability and environmental stress. Cassava also has strong potential for value-added processing into functional foods and food ingredients, including resistant starch for health-conscious consumers and individuals requiring blood glucose management, natural syrups, and ingredients for safe and high-quality processed foods. Furthermore, cassava has considerable potential to support low-carbon agricultural production and carbon sequestration, making it well aligned with global sustainability goals and emerging green trade requirements. These characteristics position cassava as an important crop for strengthening climate-resilient food security while supporting the development of future low-carbon food and bio-based industries.
9. Avocado	Cultivated area: 3,200 hectares; production volume: 18,000 tones; economic value: 300 million THB (Office of Agricultural Economics, 2026).	Variability in water availability causes fruit drop, while unseasonal rainfall increases the incidence of root rot.	– Grafting with heat- and drought-tolerant varieties suited to different elevations – Cultivation in mixed-cropping and agroforestry systems to reduce soil erosion – Quality control and quality assurance using non-destructive quality assessment and sorting technologies to enhance the value of premium products – Development of functional products tailored to the needs of specific target consumer groups	Northern Thailand has the potential to become a major production hub for superfoods and healthy fats, serving the growing health and wellness market while expanding exports to countries with high purchasing power. Sustainable production systems based on agroforestry and mixed cropping, integrating avocado with coffee, tea, and other fruit crops, can help reduce soil erosion, enhance carbon sequestration, promote biodiversity, and reduce pressure on forest areas. These practices are also well aligned with international environmental and sustainability standards. Market development can focus on premium-grade fresh avocados and cold-pressed avocado oil certified according to Halal and other internationally recognized standards, targeting premium, health-conscious consumer segments. This strategy can strengthen the value of Northern Thailand's avocado industry by emphasizing high-quality, health-oriented, and sustainably produced products rather than competing primarily on production volume.

Economic crops	Production area/Economic value	Impact and Key Challenges	Positive Adaptation	Global Opportunity
10. Macadamia	Cultivated area: 1,600 hectares; production volume: 6,000 tones; economic value: 1 billion THB (Department of Agriculture, 2018).	This crop requires a cool climate, and rising temperatures adversely affect fruit set and production investment.	– Development of AI- and GIS-based systems for production planning and site selection at suitable elevations, as well as identification of potential areas for production expansion – Development of energy efficient drying and moisture reduction technologies to preserve oil quality – Value addition through the conversion of shells into bio-based materials and renewable energy	Macadamia is widely recognized as the “King of Nuts” and is rich in unsaturated fatty acids, antioxidants, and essential minerals. It has strong potential to meet the growing demand for modern health and wellness foods, ranging from premium snacks to value-added products such as macadamia milk, nut butter, cold-pressed macadamia oil, and high-value ingredients for premium cosmeceutical products. Macadamia also has significant potential within the emerging low-carbon food sector, as perennial macadamia production systems can contribute to carbon sequestration and support the restoration and conservation of highland and headwater ecosystems. When integrated with sustainable land-management practices, macadamia cultivation can therefore contribute to both economic development and environmental sustainability. Furthermore, macadamia offers substantial opportunities for zero-waste production and bio-based industries. Macadamia shells are highly durable and have a high calorific value, making them suitable for conversion into high-quality biochar, filtration materials, biomass energy, and high-value bio-based materials. This integrated utilization of agricultural by-products supports resource efficiency, waste reduction, and value creation throughout the production chain, in alignment with Thailand’s Bio-Circular-Green (BCG) Economy model.

Turning the Global Warming Crisis into Strategic Opportunities: Thailand as the “Kitchen of the World for Global Food Security”

As global warming intensifies and natural disasters become more frequent and severe, agricultural production areas worldwide are increasingly facing production slowdowns and disruptions. In some countries, extreme events and emergency situations may even temporarily prevent the production of essential food crops. Thailand, particularly Northern Thailand, has strong potential and preparedness to adapt to climate change and respond to such emergencies. With its diverse agroecosystems, agricultural resources, technological capabilities, and resilient production systems, Northern Thailand has the potential to serve as a reliable food production base for global food security, strengthening Thailand’s position as the “Kitchen of the World.” This potential is underpinned by four key strengths, as follows:

1. Agroecological Diversity and Resilient Agricultural Systems (Agroecological Resilience)

Northern Thailand is characterized by diverse microclimates across elevations ranging from approximately 200 to more than 1,500 meters above sea level. This geographical and climatic diversity makes the region a highly agroecologically diverse production area, capable of producing a wide range of food crops under different environmental conditions. If lowland areas are affected by drought or flooding, upland and highland areas can continue to produce essential food crops and high-value agricultural commodities, thereby providing alternative production zones and strengthening the resilience of the regional food system.

The region is also supported by a strong knowledge base and a network of academic institutions and government agencies that continuously provide research, technological, and technical support for agricultural production under changing environmental conditions. Furthermore, agroforestry systems are increasingly promoted for crops such as coffee, tea, avocado, and macadamia. These systems can enhance water retention, soil restoration, and microclimate regulation by reducing temperatures within production areas, while strengthening ecosystem resilience. Collectively, these characteristics provide a sustainable nature-based buffer against climate-related and natural hazards and enhance Northern Thailand’s long-term capacity to contribute to food security.

2. Leadership in Climate-Smart Agriculture and Innovation

Through continuous advances in agricultural technology and innovation, Thailand is transitioning beyond conventional farming toward becoming a hub for the application of smart farming technologies and innovations at the farm level. One important example is low-carbon rice production through Alternate Wetting and Drying (AWD), which can reduce irrigation water use by approximately 30–50% while potentially reducing methane emissions by up to 50%. Laser Land Leveling (LLL) can also be applied to improve water-use efficiency and field management and help reduce soil erosion.

Another important innovation is the transition toward burn-free agriculture by converting maize cobs and other agricultural residues into biochar through pyrolysis. This approach can help reduce open burning and associated PM2.5 pollution, while allowing biochar to be returned to agricultural soils to improve soil structure and water retention and contribute to long-term soil carbon sequestration.

Furthermore, precision agriculture technologies are increasingly being applied to strengthen climate resilience. These include the use of drones for crop monitoring, assessment, and plant health evaluation under changing climatic conditions; smart misting systems to reduce canopy temperatures during heat stress; and AI and satellite imagery for weather forecasting, climate-risk assessment, and early warning of plant disease outbreaks. Together, these technologies can strengthen Thailand's capacity to develop a climate-smart, low-carbon, resource-efficient, and resilient agricultural production system.

3. Food Safety and Traceability Hub

During times of crisis, the world requires not only an adequate quantity and availability of food, but also food that is safe, high-quality, and traceable. Northern Thailand has a strong foundation in internationally recognized production and quality standards, including Good Agricultural Practices (GAP), organic certification, and Geographical Indication (GI). These systems strengthen consumer confidence and enhance the competitiveness of agricultural products in both domestic and international markets.

In parallel, the region continues to advance technologies and innovations for non-destructive quality and safety assessment, together with modern traceability systems across agricultural supply chains. These technologies can provide transparent and verifiable information on product origin, production practices, quality, and safety, thereby strengthening confidence among global consumers and trading partners. Such capabilities are increasingly important for accessing markets with stringent environmental and sustainability requirements, including the European Union under the EU Deforestation Regulation (EUDR). By integrating internationally recognized standards, advanced

quality assessment technologies, and traceability systems, Northern Thailand can demonstrate that its agricultural products are safe, high-quality, sustainably produced, and compliant with deforestation-related requirements, while supporting the transition toward more climate-responsible and sustainable food supply chains.

4. Logistics Capacity and Greater Mekong Subregion Connectivity (GMS Gateway)

Northern Thailand is strategically located within the Greater Mekong Subregion (GMS), providing connectivity with Myanmar, Lao PDR, southern China (Yunnan), and Vietnam through major economic corridors, including the North–South Economic Corridor (NSEC) and the East–West Economic Corridor (EWEC). This geographical advantage, combined with the continued development of cold chain logistics infrastructure, strengthens Northern Thailand’s potential to serve as a Regional Food Logistics Hub and Emergency Food Reserve Center. Such capacity would enable Thailand to rapidly distribute fresh produce, processed foods, and livestock feed ingredients to neighboring countries and international markets, particularly during crises, supply disruptions, or periods when food-producing countries experience shortages or production constraints. This strategic connectivity can strengthen the resilience of regional food supply chains and reinforce Thailand’s role as a reliable food production, storage, and distribution hub supporting regional and global food security.

Recommendations for Sustainable Adaptation

1. Strengthen investment in integrated smart water management and cold chain infrastructure through public–private partnerships (PPPs). Priority should be given to accelerating the development of smart farm-level water distribution and irrigation systems in climate-risk areas that nevertheless have strong potential for the production of specific crops. In parallel, renewable and alternative energy should be increasingly integrated into cold chain systems to improve energy efficiency and reduce food loss throughout the supply chain, from farm-level production and postharvest handling to distribution and export markets.
2. Advance the development and certification of regional agricultural carbon and environmental standards. Universities and research institutions in Northern Thailand should be strengthened to provide technical support for the assessment, verification, and certification of carbon footprints, carbon credits, and deforestation-free production standards. Establishing accessible regional certification mechanisms can help reduce certification costs for smallholder farmers while demonstrating Thailand’s commitment to environmentally responsible, low-carbon, and sustainable agricultural production.

3. Promote financial and investment mechanisms to support the transition toward climate-smart and resilient agriculture. Systematic financial mechanisms should be developed to enable farmers to adopt smart farming technologies and agroforestry systems, while improving their access to crop insurance against climate-related and natural disasters. Inclusive business models should also be established to ensure that upstream farmers can participate in and benefit from value creation throughout the agricultural supply chain, including through profit-sharing, dividends, or reinvestment in farmer livelihoods and community development. Such mechanisms can strengthen farmers' economic resilience, improve their quality of life, and enhance long-term livelihood and food security.

Although climate change presents profound challenges including food shortages, declining production capacity, and increasingly severe natural disasters that threaten national food availability and security it also creates an opportunity for regions with strong agricultural potential to play a greater role in strengthening the resilience of the global food system. Northern Thailand has significant potential to become an important production base for global food security, supported by its geographical advantages and capacity to produce a diverse range of food crops in response to changing global market demand. The region possesses rich agricultural biodiversity encompassing staple and supplementary food crops, industrial crops, and high-value agricultural commodities demanded by both domestic and international markets. This potential is further strengthened by a strong network of highly qualified researchers, academic experts, research institutions, and supporting organizations capable of developing and rapidly deploying research, technologies, and innovations in response to climate change. Combined with advances in low-carbon agricultural innovation, climate-smart production systems, internationally recognized quality and safety standards, and comprehensive logistics infrastructure, these capabilities provide a strong foundation for resilient and sustainable food production and distribution. With these strategic strengths, Northern Thailand is well positioned to transform the global climate crisis into strategic and economic opportunities, reinforcing Thailand's role as the "Kitchen of the World" and serving as a reliable production and distribution hub for high-quality, safe, nutritious, and sustainably produced food. In doing so, Thailand can make a meaningful contribution to regional and global food security while building a resilient, low-carbon, and sustainable agricultural future.

*The co-authors are working group members at the Postharvest Technology Research Center, Faculty of Agriculture, Chiang Mai University, Thailand

Contact: www.isp advisory.com

Mr. Pana Janviroj, Executive Director

Institute for Strategic Policy (ISP)

Bangkok, Thailand.

Jpana88@gmail.com