การวิเคราะห์ประสิทธิภาพการดำเนินงานโดยใช้แผนผังกระแสคุณค่าเพื่อการจัดการห่วงโซ่อุปทานสับปะรดเพื่อการส่งออกจากประเทศไทยไปยังสาธารณรัฐประชาชนจีน

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บทคัดย่อ

ระบบห่วงโซ่อุปทานสับปะรดเพื่อส่งออกจากประเทศไทยไปยังสาธารณรัฐประชาชนจีนถือเป็นผลิตภัณฑ์ทางเกษตรที่มีความสำคัญเกี่ยวกับการส่งออกสินค้าเกษตรของไทย ทั้งนี้การบริหารจัดการในระบบห่วงโซ่อุปทานยังมีปัญหาอันเนื่องมาจาก การบริหารจัดการเฉพาะปลายน้ำ การให้ความสำคัญด้านการบริหารจัดการต้นน้ำที่ไม่เพียงพอ เช่น การสรรหาเกษตรกรที่ได้มาตรฐาน การตกลงและการคัดขนาดของสับปะรด การลดการสูญเสียของการช้ำที่เกิดจากการเดินทาง ทั้งนี้วัตถุประสงค์ของงานวิจัยนี้คือ การวิเคราะห์ระบบห่วงโซ่อุปทานสับปะรดเพื่อส่งออกจากเชียงรายประเทศไทยไปยังคุนหมิง สาธารณรัฐประชาชนจีนโดยเส้นทาง R3A โดยมีการประยุกต์ใช้แผนผังสายธารคุณค่า (Value Stream Mapping: VSM) เพื่อทำการวิเคราะห์กิจกรรมที่เกิดขึ้นทั้งระบบห่วงห่วงโซ่อุปทาน โดยการเก็บข้อมูลเชิงลึกจากการสัมภาษณ์และเก็บข้อมูลจากหน้างานจริง เริ่มตั้งแต่ต้นน้ำไปจนถึงปลายน้ำ เริ่มจาก เกษตรกร โรงงานตัดแต่ง ผู้ให้บริการขนส่ง ด่านศุลกากรในประเทศไทย และผู้จัดหาจากประเทศจีน ซึ่งเป็นระบบโซ่อุปทานที่ในประเทศไทย และจากผลการศึกษาพบว่าทั้งระบบห่วงโซ่อุปทานการส่งออกสับปะรดไปยังประเทศจีนมีทั้งหมด 38 กิจกรรม ซึ่งแบ่งออกได้เป็น กิจกรรมที่ไม่เพิ่มมูลค่า (NVA) ทั้งสิ้น 5 กิจกรรม คิดเป็นร้อยละ 10.70 กิจกรรมที่จำเป็นแต่ไม่เพิ่มมูลค่า (NNVA) มี 25 กิจกรรมคิดเป็น ร้อยละ 82.12 และกิจกรรมที่เพิ่มมูลค่า (VA) มี 8 กิจกรรมคิดเป็นร้อยละ 7.18 ทั้งนี้ กิจกรรมที่สามารถปรับลดหรือลดเวลาเพื่อเพิ่มประสิทธิภาพได้แก่ ผู้จัดหารอคอยการตอบรับจากทางโรงงาน 1,440 นาที หรือการรอคอยรถบรรทุกรับสับปะรดที่สวน 60 นาที โดยการบริหารจัดการเวลา มีการคุยกันเพื่อตกลงเวลาและคุณภาพที่แน่นอน มีการร่วมมือกันระหว่างเกษตรกร โรงงานและผู้จัดหาเพื่อให้เกิดประสิทธิภาพมากที่สุด โดยมีการประยุกต์แนวคิดการผลิตแบบลีนในการร่วมมือของทั้งห่วงโซ่อุปทานจะสามารถยกระดับประสิทธิภาพและความยั่งยืนของการส่งออกผลไม้ไทยไปยังประเทศจีนได้อย่างมีนัยสำคัญ

คำสำคัญ: กระบวนการผลิตแบบลีน เครื่องมือแผนผังสายธารคุณค่า ห่วงโซ่อุปทานสับปะรด การส่งออกไปประเทศจีน

An Efficiency Analysis Using Value Stream Mapping to the Supply Chain Management of Exporting Thai Pineapples to China

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Abstract

Supply chain management (SCM) for exporting Thai pineapples to China is a critical component of Thailand's agricultural export sector. However, the export process faces significant challenges due to inadequate communication and coordination among upstream and downstream actors. For example, farmers often lack close contractual relationships with factories, shippers, and dealers, which leads to problems with product quality, post-harvest handling, and damage during processing and transportation. The aim of this study was to analyze the Thai pineapple export supply chain to China with R3A route (Chiang Rai to Kunming) by using Value Stream Mapping (VSM). Data collection involved interviews and on-site observations with all stakeholders in the export process, such as farmers, trimming factory, shippings, customs and dealers from China. The interactions among these groups are critical for identifying and minimizing waste across the supply chain. The result of this study could identified 38 activities across the supply chain. The VSM results showed 5 activities, 10.70% were NVA, 30 activities 82.12% were NNVA, and 8 activities 7.18% were VA. The activities could be reduce time and improve efficiency was NVA and NNVA. For instance, dealers waiting time confirmation from factory 1,440 mins, waiting truck to load in pineapple farm 60 mins. The principles of lean manufacturing are applied through close communication, effective collaboration, and contract farming among farmers, trimming factories, and dealers. Lead times are thereby reduced, and the efficiency of supply chain management for Thai pineapple exports to China is enhanced.

Keywords: Lean Manufacturing, Value Stream Mapping, Pineapple Supply Chain, Export to China

Introduction

Thailand's fruit industry is recognized for its significant export potential to the global market. Demanding for Thai fruits has increased significantly in recent years. China has become one of Thailand's key export market. Inyear 2016 and 2019, pineapple exports to China accounted for 86% of Thailand's total pineapple exports worldwide, with most exports consisting of the Phulae pineapple variety. Phulae pineapples are extensively cultivated in Chiang Rai Province (Ferreira et al., 2022). In year 2022, Thailand's pineapple industry generates approximately 39,601 million baht in income, with most of the economic benefits retained domestically through employment and raw material utilization (Food Intelligence Center, 2017). In figure 1 shown the pineapples are processed into a variety of value-added products. In 2020, the export volume reached 290,578.34 tons, accounting for approximately 13,207 million baht in export value (Food and Agricultural Organization of The United Nations FAO, 2022).

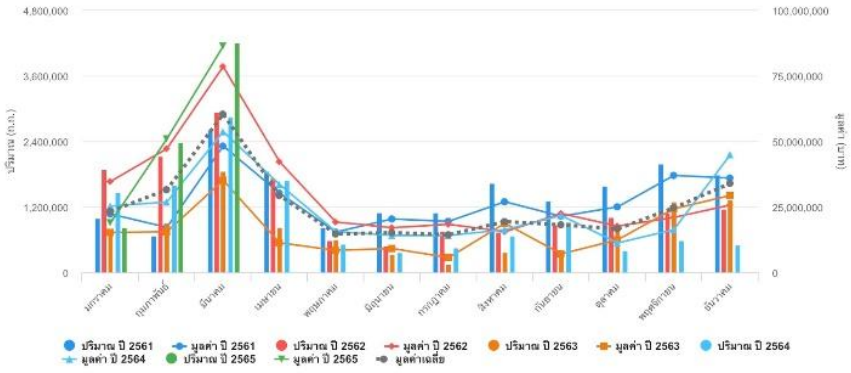

Figure 1: Export statistics on fresh or frozen pineapple exports

(Office of Agricultural Economics, 2022)

Factories that export pineapples must comply with the following standards: GMP, DOA, HACCP, GACC, SPS, PC, and GHP. In addition, exporters must possess Form E documents for trade with China. The export route goes through Chiang Khong District via Route R3A. It passes Huai Sai Checkpoint in Bo Kaeo Subdistrict, Laos, and continues to Kunming, Yunnan Province, China. R3A route is considered the most efficient, covering a total distance of approximately 1,240 kilometers. The export of Thai pineapples to China involves complex processes across the upstream and downstream supply chains. Key challenges include inconsistent product quality and damage incurred during transportation. Inadequate selection of farmers required to comply with Good Agricultural Practice standards significantly contributes to these issues. Furthermore, insufficient skills in cutting and trimming operations at processing factories present an additional gap that adversely affects overall pineapple quality.

Lean manufacturing is an improvement tool used to reduce costs and time and enhance efficiency across various companies. Reducing unnecessary activities and controlling inventory levels helps companies save costs (Ditkaew, 2022). Value Stream Mapping (VSM) is a conceptual tool in lean

thinking used to visualize all processes and activities. It focuses on reducing process steps or eliminating unnecessary activities to improve efficiency. VSM classifies activities into Value-Added (VA), Non-Value-Added (NVA), and Necessary but Non-Value-Added (NNVA). NVA and NNVA activities are major challenges for companies that need to be addressed in order to improve efficiency. Phuangsubsin (2024) and Ferreira (2022) applied Value Stream Mapping (VSM) to improve operational efficiency and analyze material flows within the production process. VSM can be used to improve the time and efficiency of Thai pineapple export supply chain to China. The supply chain involves multiple stakeholders, which often leads to process inefficiencies and delays. These time losses can negatively affect pineapple quality, as pineapples are perishable goods.

Research Objective

1. The aim of this study was to analyze the Thai pineapple export supply chain to China using Value Stream Mapping (VSM) to classify activities as Value Added (VA), Non-Value Added (NVA), or Necessary but Non-Value Added (NNVA).

2. To analyze the Thai pineapple export supply chain by examining the interactions among farmers, factory operators, laborers, and transporters in order to identify and reduce waste throughout the supply chain.

Scope of the study

The Thai pineapple export supply chain comprises all parties involved in the export process 2 exporter, 2 farmers, 1 operation factory, 2 Transportation company, 2 document company, 1 agent company and Thai custom. Value Stream Mapping was applied to analyze the current state and identify the future state of the supply chain. The participating organizations were selected from a major pineapple exporting company. Data collection involved interviews and on-site observations. This study was conducted in Chiang Rai Province, Thailand, in 2023.

Research framework

This research focuses on analyzing all steps and processes within the Thai pineapple export supply chain. The framework begins with the purchasing activities initiated by Chinese agents, followed by interactions with Thai merchants and farmers. It then covers the stages of product sorting, preparation, documentation, inspection, and transportation through Thai customs, continuing across the Lao border, and finally reaching China as shown in figure 2. Exporting pineapples to China involves not only the physical shipment of products but also strict quality inspection and regulatory compliance. Given the short shelf life of pineapples, effective supply chain management is essential to ensure rapid and timely delivery. Therefore, this paper aims to examine and analyze a case study of the pineapple export supply chain to China. Data collection involved interviews and on-site observations.

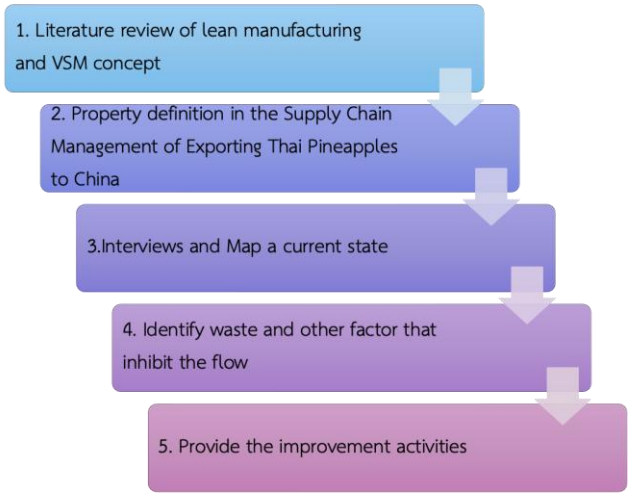

Figure 2: The VSM Steps for the the Supply Chain Management of Exporting Thai Pineapples to China

Literature Review

The physical characteristics of the Phulae pineapple

Phulae pineapples have slender, light green leaves with a pink stripe along the leaf edge and thorns running the length of each leaf. The fruits are small, weighing 1-1.5 kg *(*Kongsuwan et al., *2009)*. The pips are usually long, erect, and pointed, about 1 to 1.5 times the length of the fruit (Arwatchananukul et al., 2025). The quality of appearance and taste, which are observable external traits, is commonly used as the standard criterion.

Documents for exporting fruit from Thailand to China.

Document for exporting to China must comply with Chinese import regulations. In particular, there are hygiene and safety requirements for fruits that all importers must follow. Currently, the Chinese Customs Authority is responsible for overseeing health and safety inspections. Their oversight is a key part of the import approval process. Chinese fruit importers must hold a valid fruit import license to import fruit.

-CheckList of Exporting Fruit

- Plant stew must be removed and packed using appropriate methods under the supervision of the Ministry of Agriculture and Cooperatives.
- A hygiene certificate (PC) must be accompanied at all times. Producing farmers must register as exporters with the Department of Agriculture and apply for GAP and GMP certification. Exporting farmers must request a Phytosanitary Certificate or PC from the Department of Agriculture to attach to the products to be exported.
- The 10 types of fruit exported from Thailand must come from GAP-certified plantations and GMP-certified packing plants and have been registered by the Thai Department of Agriculture and Chinese agencies before shipment.

- Thai fruits exported to China No need to pay import taxes You must have a Certificate of Origin (Form E) to show to Chinese customs.

Lean Manufacturing

Lean manufacturing was introduced by Toyota Company, focusing on creating value by eliminating waste in all activities (Touriki et al., 2021). Lean manufacturing also promotes the efficient use of production resources, shortens production lead times, and enables higher quality, lower costs, and greater production flexibility. Lean manufacturing identifies eight wastes for analyzing non-value-added activities: defects, overproduction, waiting, unused talent, transportation, inventory, motion, and over-processing. Waste has a significant impact on organizational processes and, therefore, needs to be reduced or eliminated (Hossain & Purdy, 2023). Lean concepts have been applied in agricultural production to eliminate waste in operational processes, crop maintenance, and harvesting activities (Salano et al., 2019; Carrijo et al,2024). Lean tools such as Value Stream Mapping (VSM), PDCA, and 5S have been implemented in agricultural crop production to reduce waste in operational processes (Martins et al, 2023).

Value stream mapping

A value stream map is an important tool for studying the values or needs that arise from the customer's perspective. This diagram is therefore used to provide an overview of the entire process flow taking place (Heydarzade et al., 2025). Activities that do not create added value and activities that need to be done but do not add value Therefore, value stream diagrams are important to separate waste or waste for future improvement. Future state map (Naeemah & Wong, 2023). The process of doing activities (VA, NVA, NNVA) is the mapping of the value stream, which is used to classify activities into 3 types as follows (Dara et al., 2024). Value Added (VA) activities involve changes in form or value that transform raw materials into finished products. Necessary but Non-Value Added (NNVA) activities do not add value to the product but are required to support the process and therefore cannot be completely eliminated. These activities are often associated with the seven types of waste, namely transportation, inventory, motion, waiting, overproduction, overprocessing, and defects. Non-Value Added (NVA) activities do not add any value to the product and represent pure waste that should be eliminated from the process. A coffee farm implement VSM to explore the agriculture operation process and increasing the productivities by improve time and proess (Carrijo et al,2024). A Swedish dairy farm applied Value Stream Mapping (VSM) to improve process efficiency by eliminating waste and enhancing value flow (Melin & Barth, 2020). Value Stream Mapping (VSM) has become a widely used approach for improving production processes. It provides a clear and easy-to-understand visualization of process flows, enabling organizations to align goals and share information effectively.

Research Methodology

This research is a field study that involved direct interviews with individuals participating in the export of pineapples from Chiang Rai Province, Thailand, to Kunming, China. The sample group comprises pineapple export companies to China, with data collected in Chiang Rai Province. A large export company was selected as the case study. Data collection involved interviews and on-site observations. The interview questionnaire was designed to examine processes and activities in the pineapple export supply chain and to collect actual processing time data. The research and data collection were conducted in the following stages:

1. To collect the data on pineapple export standards and regulatory requirements for shipments routed through the Chiang Khong Customs checkpoint to China.

2. Data on the Thai pineapple export supply chain were collected from key stakeholders, including two exporters, two farmers, one factory operator, two transportation companies, two documentation companies, one agent company, and Thai Customs.

3. Summarize the activities along the Thai pineapple export supply chain to China via the R3A route using Value Stream Mapping (VSM), encompassing all parties involved in the process, including farmers, factory operators, laborers, transporters, and consumers.

4. To analyze the supply chain using VSM by classifying VA, NVA, and NNVA activities to identify waste and evaluate performance, time using average.

5. To evaluate the Thai pineapple export supply chain to China based on the results of the Value Stream Mapping (VSM) analysis.

6. To summarize and discuss the research findings.

Research Result

This research examined the supply chain activities involved in cross-border trade to the People's Republic of China using the Value Stream Mapping (VSM) methodology. The focus is on the trimmed pineapple supply chain from order placement by Chinese customers through dealers, factories, and agricultural producers to export via customs and delivery to customers in China, as illustrated in Figure 3.

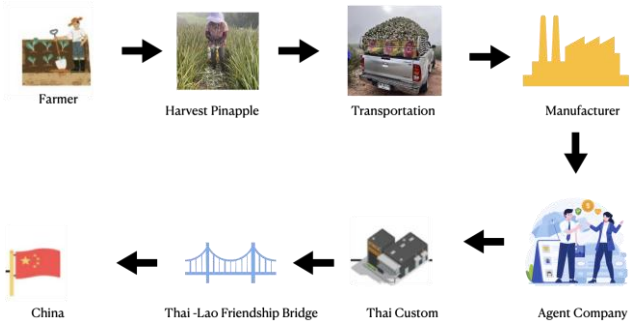

Figure 3: Supply Chain of Thailand's Pineapple Exports to China

This research examined the supply chain activities involved in exporting trimmed pineapples from Thailand to the People's Republic of China using the Value Stream Mapping (VSM) methodology. Six groups within the supply chain were studied covering the entire process from order placement to delivery. The process begins with dealers receiving orders from Chinese customers, typically through middlemen. Dealers forward the orders to factories, which coordinate with farmers to prepare the required quantity of pineapples. The factories collect pineapples from farmers and select them based on size criteria. The pineapples are then cleaned with water, peeled, and trimmed for visual appeal. Following this, the pineapples are placed in plastic baskets, rinsed twice with water, and rinsed with salt water to maintain freshness and hygiene. After draining and drying, the pineapples are packed into PE plastic bags, sorted by color and size, and checked in foam crates for secure packing.

For export, the necessary documents including phytosanitary certificates, certificates of origin, and product declarations are prepared for inspection by the Department of Agriculture. Export information is entered into the customs system, and the goods are transported from the factory to the customs checkpoint. Cross-border transportation involves transferring goods from Thailand to the Lao PDR, changing tractor heads at the Huai Sai checkpoint, and then transporting the goods from the Bo Ten border checkpoint to the Kunming market in China. Finally, the pineapples are delivered to Chinese customers.This comprehensive approach provides a clear overview of the current "as-is" supply chain, enabling analysis of value-added and non-value-added activities and informing the design of a future state to improve efficiency and resilience in the cross-border pineapple export proce

Table 1 Value Stream Mapping of the Pineapple Export Supply Chain

Partner	No.	Activity	Average Time (Minute)	Operation	Transportation	Inspection	Wait/Store	VSA
Dealer	1	Dealer order through middlemen.	4,320	NNVA				NNVA
	2	The factory takes orders from middlemen.	1,440	NNVA				NNVA
	3	The factory sends pineapple orders to farmers.	1,440	NNVA				NNVA
Farmer	4	Harvesting (cut off the skin and cut off the head of the pineapple.)	120	VA				VA
	5	Farmers select size and color	120			VA		VA
	6	Transportation of a pineapples by trucks	60		NNVA			NNVA
	7	Transportation of pineapples to the factory (approximately 80 km.)	120		NNVA			NNVA
Trimming factory	8	Selection of pineapple sizes (according to factory standards) per 1 ton	60			NNVA		NNVA
	9	Clean the pineapple with salt water for the first time	60	VA				VA
	10	Peeling and trimming	240	VA				VA
	11	Placing pineapple in a plastic basket and soaked for cleaning with water	180	NNVA				NNVA
	12	Time 2 for washing process with water	120	VA				VA

Partner	No.	Activity	Average Time (Minute)	Operation	Transportation	Inspection	Wait/Store	VSA
	13	Washing pineapple 3 times with salt water	60	VA				VA
	14	Dry the pineapple to drain the water	60				NNVA	NNVA
	15	Packing pineapple in PE plastic bag separated by color and size	240	VA				VA
	16	Pack tightly into a foam crate filled with wax and wait for pickup	60				VA	VA
	17	The transport company receives orders to pick up products from the cutting factory	1,440	NNVA				NNVA
	18	Confirmation orders to pick up products at the shipping factory and send them to the factory	1,440	NNVA				NNVA
Shipping	19	Waiting for confirmation to receive the product at the factory	1,440	NVA			NVA	NVA
	20	Inspection and receiving pineapple from the factory	10			NNVA		NNVA
	21	Submit phytosanitary certificate documents (Certificate of Origin, Form B) and declaration	10	NNVA				NNVA
	22	Filing out export information in file system	10	NNVA				NNVA
	23	Waiting for the car to come pick up the product	60				NVA	NVA
Shipping	24	Cleaning and disinfecting containers before transporting the product	60	NNVA				NNVA
	25	Adjusting the cabinet temperature to 8 degrees	60	NNVA				NNVA
	26	Transporting container (conveying method: 1 truck container)	120		NNVA			NNVA

Partner	No.	Activity	Average Time (Minute)	Operation	Transportation	Inspection	Wait/Store	VSA
	27	Fill out the document (Form E)	10	NNVA				NNVA
	28	Waiting to receive documents from the factory (Form E)	10				NVA	NVA
	29	Close the seal from the Department of Agriculture	7			NNVA		NNVA
	30	Move goods to Chiang Khong checkpoint	120		NNVA			NNVA
Custom	31	Bring the car in for weighing (1 car) in Chiang Khong Custom	5			NNVA		NNVA
	32	Official custom check documents and the status of goods	5	NNVA				NNVA
	33	Issue a weight sheet to the driver	2	NNVA				NNVA
	34	Change transfer heads from Chiang Khong Customs to at Huai Sai Checkpoint, Lao PDR	90	NNVA				NNVA
	35	Waiting to replacing Container heads at Huai Sai checkpoint, Lao PDR	5				NVA	NVA
	36	Transportation from the tractor exchange point from Huai Sai checkpoint to Boten checkpoint,	420		NNVA			NNVA
	37	Waiting to replacing Container heads at Bo Ten checkpoint, China	5				NVA	NVA
	38	Cross-border transportation from Bo Ten border to destination at Kunming Market, China	180		NNVA			NNVA
Total			**14,209**					

Table 2 The breakdown of activities occurring in the supply chain.

Activities	Operation time (Minute)	Percentage (%)
Value-added activities (VA)	1,020	7.18%
No value-added activities (NVA)	1,520	10.70%
Necessary non-value-added activities (NNVA)	11,669	82.12%
Total	14,209	100%

Table 2 provides an overview of activities in the pineapple supply chain from production in Thailand to export to China. Data were collected from the agricultural sector, factories, transport companies, and the Chiang Khong customs checkpoint. Analysis revealed that completing activities from the factory to the tractor change point at the Huay Xai checkpoint in Lao PDR took a total of 14,209 minutes. These activities were classified as follows: non-value-added (NVA), consisting of 5 activities and accounting for 10.70%; necessary but non-value-added (NNVA), consisting of 25 activities and accounting for 82.12%; and value-added (VA), consisting of 8 activities and accounting for 7.18%. Waiting time is a form of non-value-added activity that can be reduced or eliminated through effective coordination and management among supply chain participants. For example, contractual arrangements among farmers, processing factories, and transportation providers can be used to schedule operations more efficiently, thereby reducing this source of waste. NNVA is an activities that cannot improve the value of pineapple but need to do. For this activities can be improve by improve of training of staff, operation of cutting infarm, peeling steps, packing.

Lean implementation

The analysis tool is used to examine an organization’s business environment through the principles of lean manufacturing. This analysis helps organizations better understand their business processes and improve operational efficiency. It also identifies potential opportunities and obstacles that may arise in the future, supporting strategic planning and operational decision-making. The analysis is presented for a four-party supply chain of pineapple exports to China.

Farmers

The transportation time and truck loading after harvesting are considered necessary but non-value-added (NNVA) processes. These activities can be optimized by reducing unnecessary steps and improving time management through closer communication of key information, such as total tons, number of staff, and number of trucks. Effective management of the loading process can help farmers minimize product loss and damage.

Trimming factory

Managing pineapple attributes, such as size, color, and sweetness level, can address quality-related issues that are necessary but non-value-added (NNVA) activities. Improving the efficiency of dealers' demand and supply management presents an opportunity for factories to trim production

costs. Additionally, staff training is essential to maintain quality standards and minimize product damage.

Export Companies

Identifying factories or farmers that meet Chinese regulatory standards is essential. Joint ventures or strong collaboration can support the development of long-term, mutually beneficial relationships. Free Trade Agreement (FTA) provide Thailand's export market with more opportunities to enter new markets.

Customs

E-Customs is a digital system that streamlines the submission and verification of export and import documents. It improves efficiency by reducing manual paperwork, speeds up processing, and enhances transparency in cross-border trade. Documents are used to certify the quality and compliance with standards of farmers' products, as well as of production and trimming factories. Examples include PC, HACCP, GAP, GMP, DOA, SGS, and ISO certifications. For exporting pineapples from Thailand to China, Form E is used.

Conclusion and Discussion

This study examined the supply chain of pineapples from Chiang Rai, Thailand, to Yunnan Province, China, by using Value Stream Mapping (VSM). The supply chain exporting pineapple consist of 5 parties, dealer, farmer, trimming factory, shipping and customs. Activities were classified as value-added (VA), necessary but non-value-added (NNVA), and non-value-added (NVA). Waiting activities (NVA) related to dealer and farmer confirmation and vehicle availability for transporting pineapples to the factory can be reduced through effective management practices, thereby shortening processing time and improving operational efficiency. NNVA activities may enhance operational efficiency by providing staff training in specific tasks, such as packing, cutting, or peeling pineapple. Streamlining these steps will reduce total lead time, increase product throughput, minimize losses, and enhance the performance of the pineapple export supply chain. The documentation required for importing agricultural products into China is classified as an NNVA activity. These documents are essential for fruit exports and must comply with regulations, including the Phytosanitary Certificate, Good Agricultural Practice (GAP), Good Manufacturing Practice (GMP), Hazard Analysis and Critical Control Point (HACCP), and Form E. The identification of waste and value flow has been successfully applied to improve yield and quality in milk production (Melin & Barth, 2020) and crop production (Martins et al., 2023). Similarly, the implementation of Value Stream Mapping in coffee farming has been used to illustrate current and future activity flows in order to enhance productivity and operational performance. In line with the findings of Sasipha et al. (2019), who employed VSM to examine the mangosteen supply chain in Chanthaburi province and reported that waiting time constituted 21% of the process and that 19 NNVA activities were present, the present study likewise demonstrated a reduction in process inefficiency by

removing the waiting period that previously occurred prior to the temperature-inspection stage. Clorlear et al. (*2015)* applied VSM to identify waste within the automatic rice-steamer logistics and supply chain in Ubon Ratchathani province. Their results indicated that waste in the supply chain could be reduced by approximately *5.03* days through improved inventory control and management. This highlights that a significant portion of the supply chain involves activities that, while necessary, do not directly add value to the product. The findings offer practical recommendations for farmers, factory operators, and logistics service providers to enhance operational performance. These recommendations also facilitate more effective responses to the increasing demand for Phulae pineapples in the Chinese market.

Recommendations

1. The implementation of this study aims to improve the efficiency of the entire supply chain process for exporting Thai pineapples to China. Collaboration among the five logistics stakeholders can reduce lead time and enhance operational management.

2. Further research should systematically identify barriers within the Thai pineapple export supply chain to China, such as challenges related to e-Customs systems, phytosanitary certification, and coordination among farmers, dealers, and factories. Additionally, future studies should develop targeted strategies to address these barriers and close existing gaps in the supply chain, particularly by minimizing waiting times at border crossings.

References

Arwatchananukul, S., Chaiwong, S., Charoenkwan, P., Punvichai, T., Chen, M., & Saengrayap, R. (2025). Classification of translucent flesh defects in phulae pineapples using stacking ensemble classifiers and deep neural networks. *Applied Food Research*, *5*(2), 101460.

Carrijo, P. R. S., Rader, M. L. B., Batalha, M. O., Filho, G., (2024). Lean manufacturing in agriculture: adapting the value stream mapping approach for farm management, Volume 17, pages 1444–1468.

Dara, H. M., Raut, A., Adamu, M., Ibrahim, Y. E., & Ingle, P. V. (2024). Reducing non-value added (NVA) activities through lean tools for the precast industry. *Heliyon*, *10*(7), e29148. https://doi.org/10.1016/J.HELIYON.2024.E29148

Ditkaew, K. (2022). The Effect of Lean Accounting Implementation on Organizational Performance. *International Journal of Asian Business and Information Management*, *13*(1). https://doi.org/10.4018/IJABIM.309134

Ferreira, W. de P., Armellini, F., Santa-Eulalia, L. A. de, & Thomasset-Laperrière, V. (2022). Extending the lean value stream mapping to the context of Industry 4.0: An agent-based technology approach. *Journal of Manufacturing Systems*, *63*, 1–14. https://doi.org/10.1016/J.JMSY.2022.02.002

Heydarzade, A., Rezaei, N., Vaezi, S. A., & Camelio, J. A. (2025). Multi-layer multi-variable value stream mapping: A comprehensive framework across operational, environmental, and social layers with integrated KPIs interrelationships. *Manufacturing Letters*, *44*, 184–194. https://doi.org/10.1016 /J.MFGLET.2025.06.023

Hossain, M. M., & Purdy, G. (2023). Integration of Industry 4.0 into Lean production systems: A systematic literature review. *Manufacturing Letters*, *35*, 1347–1357. https://doi.org/10.1016/ J.MFGLET.2023.08.098

Kongsuwan, A., Suthiluk, P., Theeppakorn, T. and Srilaong, V., 2009, Bioactive compounds and antioxidant capacities of phulae and nanglae pineapple, Asian Journal Of Food & Agro-industry. Special Issue, S44- S50.

Martins, A. D. O., Anjos, F. E. V., Silva, D. O. The Lean Farm: Application of Tools and Concepts of Lean Manufacturing in Agro-Pastoral Crops. Sustainability, Vol. 15(3), 2597

Melin, M., Barth, H. 2020. Value stream mapping for sustainable change at a Swedish dairy farm. Int. J. of Environment and Waste Management, Vol. 25, No. 1. P. 130-140.

Naeemah, A. J., & Wong, K. Y. (2023). Sustainability metrics and a hybrid decision-making model for selecting lean manufacturing tools. *Resources, Environment and Sustainability*, *13*, 100120. https://doi.org/10.1016/J.RESENV.2023.100120

Phuangsubsin, C., Jantakard, H., & Vinitpittayakul, K. (2024). Risk Assessment of Sustainable Pineapple Supply Chain Management. In *Thai Environmental Engineering Journal* (Vol. 38, Issue 1).

Salano, N. E. C., Llinás, G. A. G., Torres, J. R. M. (2019). Towards the integration of lean principles and optimization for agricultural production systems: a conceptual review proposition. Vol. 100. Iss. 2. P. 453-464.

Touriki, F. E., Benkhati, I., Kamble, S. S., Belhadi, A., & El fezazi, S. (2021). An integrated smart, green, resilient, and lean manufacturing framework: A literature review and future research directions. *Journal of Cleaner Production*, *319*, 128691. https://doi.org/10.1016/J.JCLEPRO.2021.128691