



## Study of Logistics and Supply Chain Management of Teak Wood Product Industry in the Northern Part of Thailand

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### Abstract

The purpose of this research was to study the structure of supply chain and logistics system, cost analysis, operation problems, and make recommendations for efficient improvement in whole supply chain of teak wood product industry. The methodology comprised data collection, literature review, direct observation, and structural interview from the northern part of Thailand. The results showed the structure of the supply chain both in users and products, and the flow of process in forestry plantation operation, collaboration between sawmills and forestry plantations, and overall operations of cooperatives were mentioned. The study presented problems and suggestions as follows: (1) Physical flow of teak products: the policy and the law were main problems; therefore, the government should analyze such and make up-to-date; (2) Complicated track and trace of logs and processing: new machinery and technology to support such should be developed; (3) Information flow lacked coordinated system, duplicated document operation, and outdated accounting system: integrated information system should be developed; (4) Community, problem in forming cooperatives and lack of confidence of private sector to invest: the government should educate and build confidence; (5) Value addition, teak retailers lack processing technology and market demand; (6) Lack of research to develop various product formats; and (7) Underpricing from middleman, which requires cooperation between public and private sector to solve the problems. As a consequence, such can lead to improving and developing the planning of teak plantation in the northern part of Thailand, such as transformation process, value added and cost effectiveness in the operation of whole teak supply chain.

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## Introduction

Teak is a popular economic wood in Thailand. The Royal Forest Department supports forestry plantations for increasing both cultivation area and revenue under the plan to promote integrated economic timber for 20 years from 2018–2036. The Forest Industry Organization [FIO] reported that teak plantation timber was approximately 71,954.53 cu. m. or around 25.25 percent of total timber production of Thailand in 2018. Furthermore, the Ministry of Commerce informed that the number of timber and wood product exports of Thailand to foreign countries especially China, Japan, the United States and countries in the Middle East, namely, the United Arab Emirates and Saudi Arabia, were worth approximately 1.1 billion baht in 2018. The maximum value of exported sawn timber was about 39 billion baht. This was followed by exported furniture and parts, with the export value around 30 billion baht. The third was exported fiber board of approximately 1.9 billion baht. In addition, Thailand is the number one in Asia in teak industry, particularly sawn timber and furniture, the top two wood imports into Thailand, at nearly 579 million baht per year, and around 1,404 cu m. of teak logs were imported, worth nearly 30 million baht. Therefore, this indicates that Thailand still has an opportunity to increase the value of wood product exports.

In the past, there was not much research on logistics and supply chain management in the forestry or lumber industry. There were no studies of logistics and supply management costs in the forest plantation and sawmill of the Forest Industry Organization. However, there was research by Prommayanon, Asapawiriya, Srinaruwan, and Sathit (2019), who studied about value chain management model for the manufacture of teak timber at forest plantation of Upper Northern Forestry Industry Organization. Prommontree (2013) studied supply chain management for Parawood manufacturing with Failure Mode and Effect Analysis: (FMEA) in Songkhla province. Therefore, the researchers focused on a study in logistics and supply chain management of teak wood product industry, including: (1) the structure of supply chain and logistics system; (2) the analysis of cost; (3) the problem of operation; and (4) the recommendation for efficient improvement in logistics management in teak wood product industry, in order to analyze the management that can meet the needs and enhance the satisfaction level of customers. The study considered the coordination of production, inventory, location and logistics of whole teak supply chain, resulting in the best solution, both cost competitiveness and customer satisfaction.

## Methodology

Data collection in this study during January to December in 2019 included the following steps:

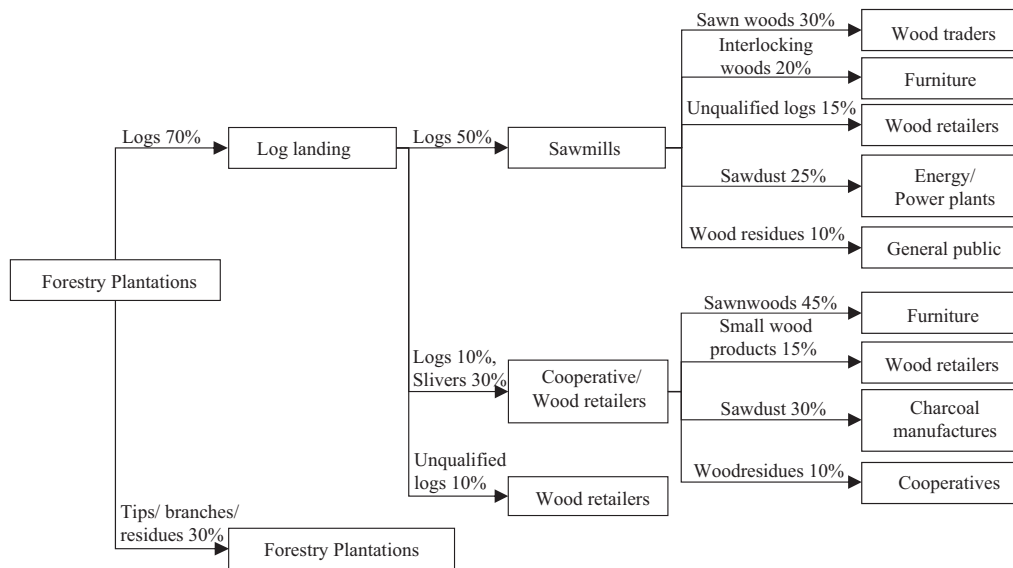
1. Study the teak industry, including the supply chain structure of teak in all levels, and the process and cost of each activity of logistics management, by collecting primary and secondary data from three plantations (Wang Chin, Kun Mae Kham Mi, and Mae Haad) with approximately 11.45 percent of the northern part of Thailand (Forest Industry Organization [FIO], 2017), log landings, Forest Industry Organization [FIO] in Phrae province and Lampang province, sawmills, cooperatives, and Provincial Office of Natural Resources and Environment Phrae, with direct observation, and structural interview from managers and workers in forestry plantation, cooperative teak production administrators, and customers in Phrae province. The in-depth interviews were arranged around 15 people for 8 times. The direct observation on site was about 3 days per part. The Forest Industry Organization, furthermore, was also separated into three parts for gathering data; semi-structural interview, step by step observation in the process, and financial study in secondary data of FIO. In this step, procedures, costs and problem in whole teak supply chain were collected and analyzed carefully.

2. Collect problems of current logistics system from plantation to transportation to factory by using data collection methodology comprising observation and structural interview with forestry plantation, cooperative, transportation agencies, sawmills, FIO, wood trader, and furniture factories. Apply problem analysis of current logistics system with Root Cause Analysis technique from the secondary data with various reliable organizations, for instance forestry plantation, FIO, Royal Forest Department, and Ministry of Commerce in order to consider information flow, cost analysis, and recommendations for optimal solutions.

## Results

### *Part 1 Components of Teak Product Industry Supply Chain: Teak Wood Users*

Teak product industry supply chain with users included forestry plantation, sawmills, cooperative, wood traders/retailers, furniture factories/retailers, wood retailers, energy companies/power plants, charcoal manufactures, and general public, as seen in the following Figure 1.



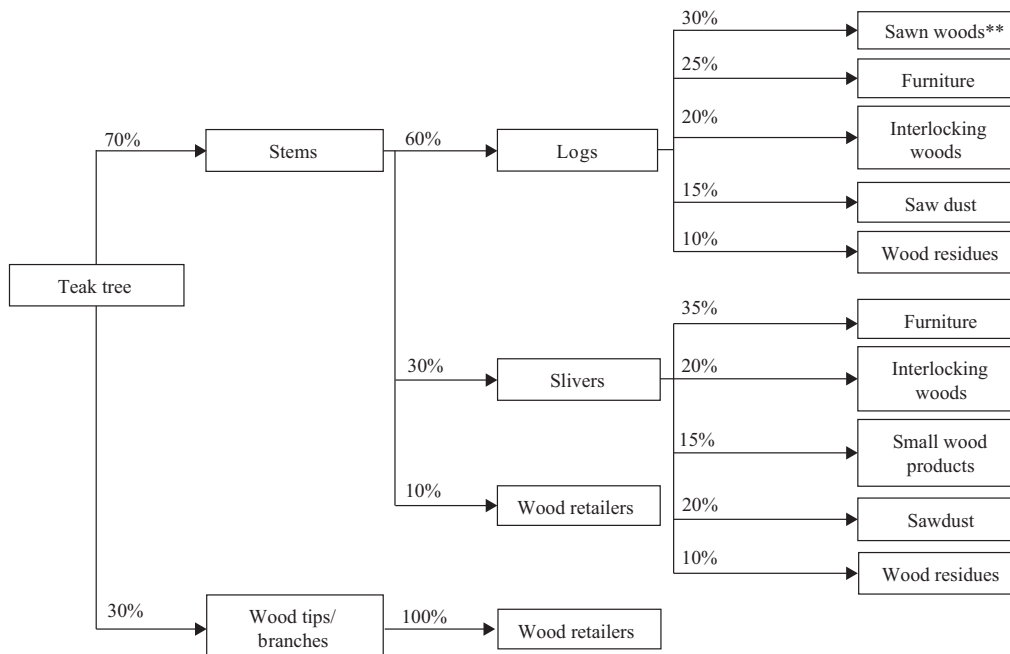
**Figure 1** Components of Teak Product Industry Supply Chain: Teak Wood Users

*Part 2 Components of Teak Product Industry Supply Chain: Products*

Components of Teak Products Industry Supply Chain: Products include teak trees, stems, wood tips/branches, logs, unqualified logs, sawn woods, interlocking woods, furniture, small teak products, sawdust, and wood residues, as seen in the following Figure 2.

*Part 3 Operations of Teak Product Industry Supply Chain Components*

This research aimed at studying operations only upstream of the teak products industry supply chain, namely forestry plantations, sawmills, and cooperatives with the following results:



**Figure 2** Components of Teak Product Industry Supply Chain: Products

Note: \* Wood residues in forestry plantations and lumber yards; \*\* Structures and construction materials.

*Forestry plantations*

Forestry Plantations had several processes for operatives as shown in the following figure 3.

Log selling was separated into two procedures; namely, direct sell and auction, as seen in the following Figure 4 and Figure 5 respectively.

*Sawmills*

The important procedures in the Forest Industry Organization sawmills were divided into two processes: namely, (1) cooperating process with forestry plantations following Figure 6.

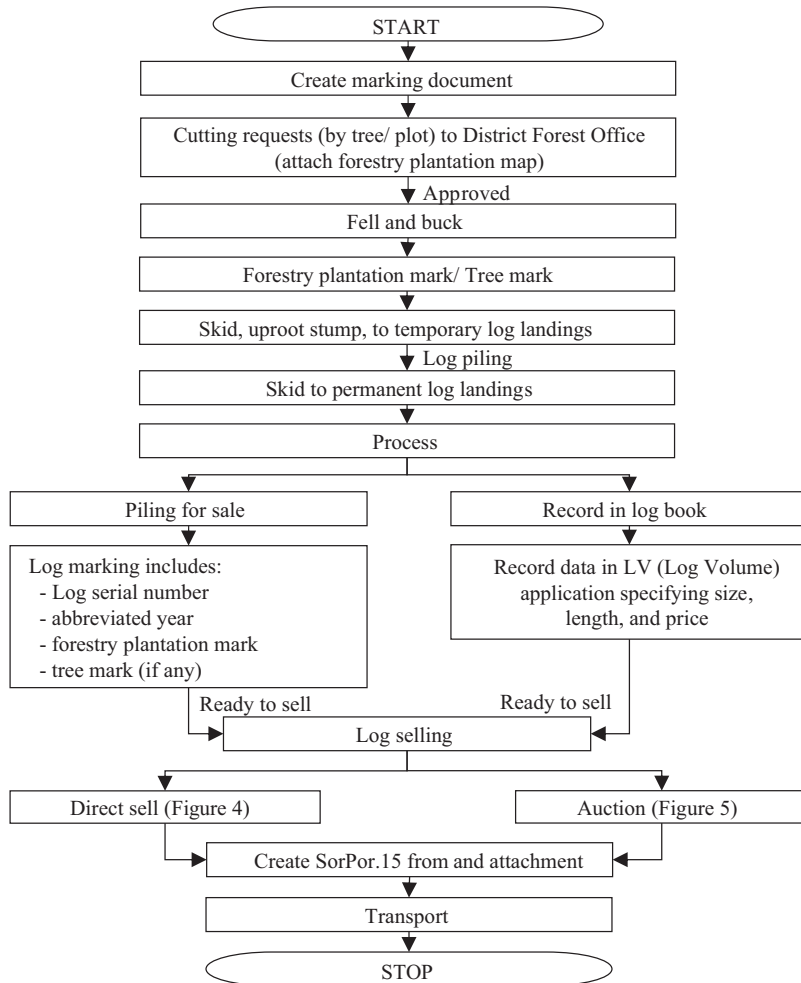
The operation process of sawmills as within the following Figure 7, and the sub-process of the wood processing procedure of sawmills within Figure 8.

*Cooperatives*

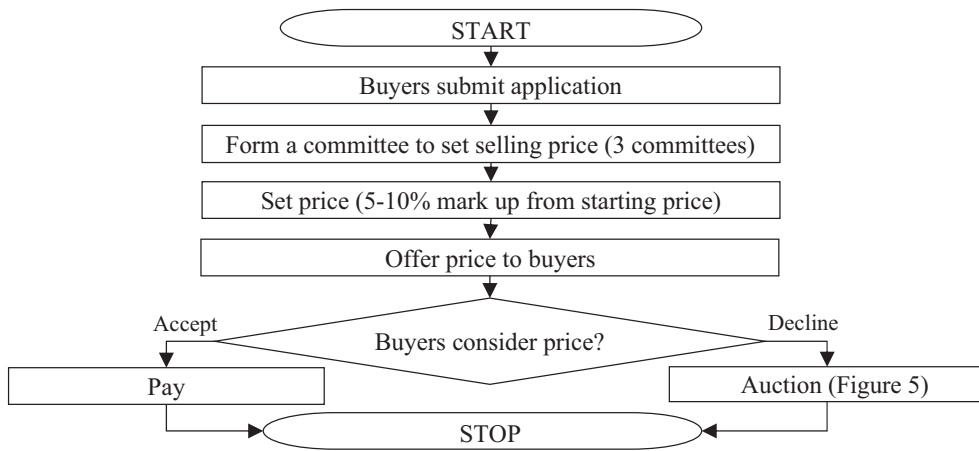
The operation procedure of teak cooperatives is shown as in the following Figure 9.

*Part 4 Cost of Logistic Management and Supply Chain of Teak Product Industry*

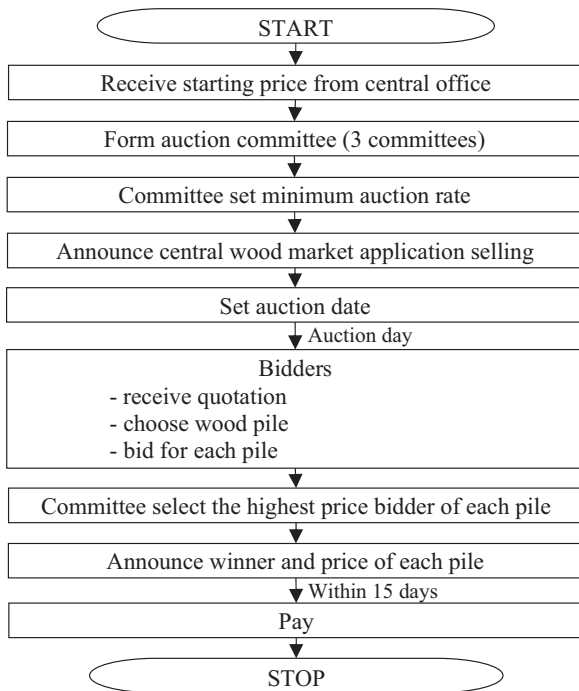
The study of cost of logistics management and supply chain of teak product industry aimed at (1) forestry plantations and (2) the FIO sawmills in Phrae province and focused on cost of each activity in the entire process as shown in the study result of Part 3; Operations of Teak Product Industry Supply Chain Components. Details of the study are as follows:



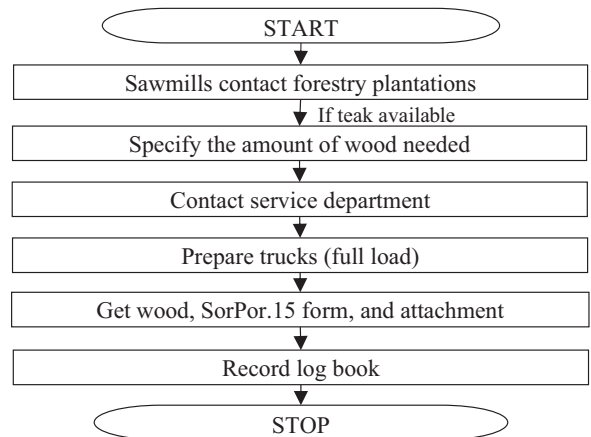
**Figure 3** Forestry Plantation Operation Procedure



**Figure 4** Teak direct sale process of forestry plantations



**Figure 5** Auction process of forestry plantations



**Figure 6** Cooperating process with forestry plantations: Forest Industry Organization Sawmill

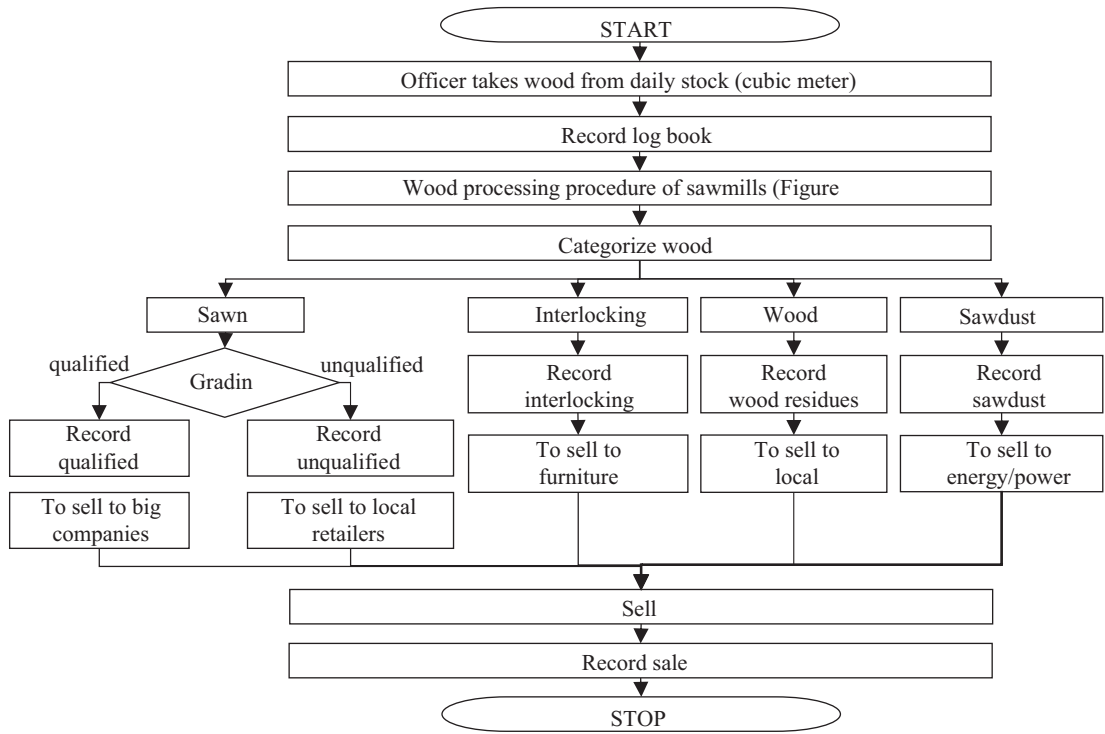


Figure 7 Operation process of sawmills

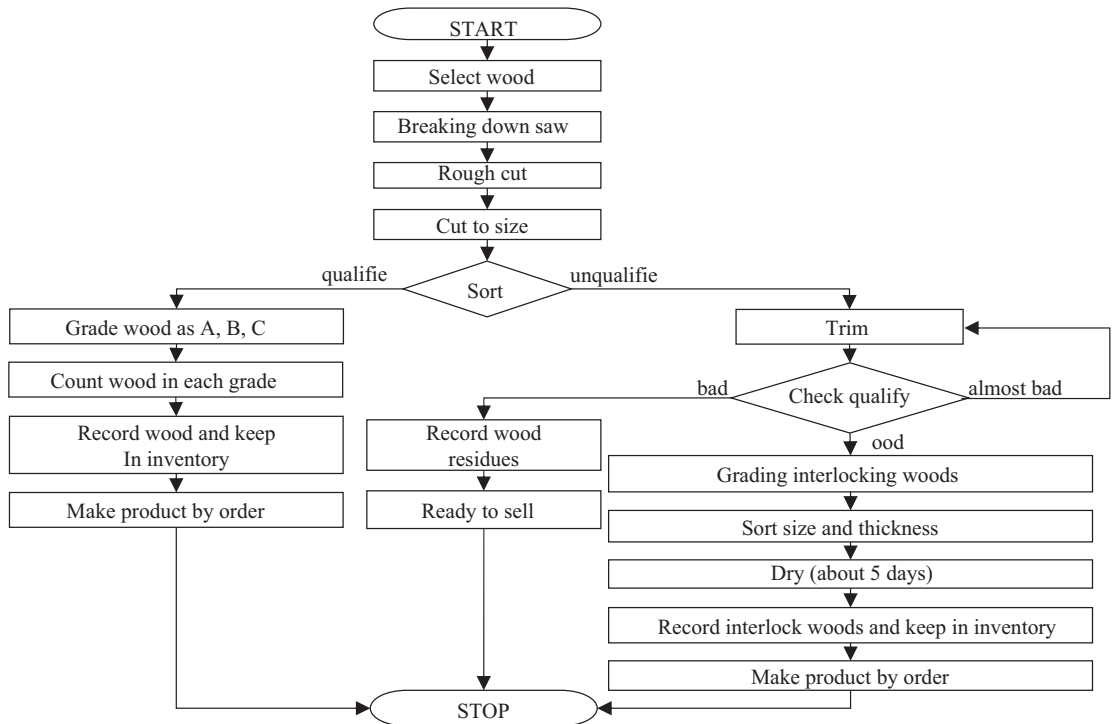
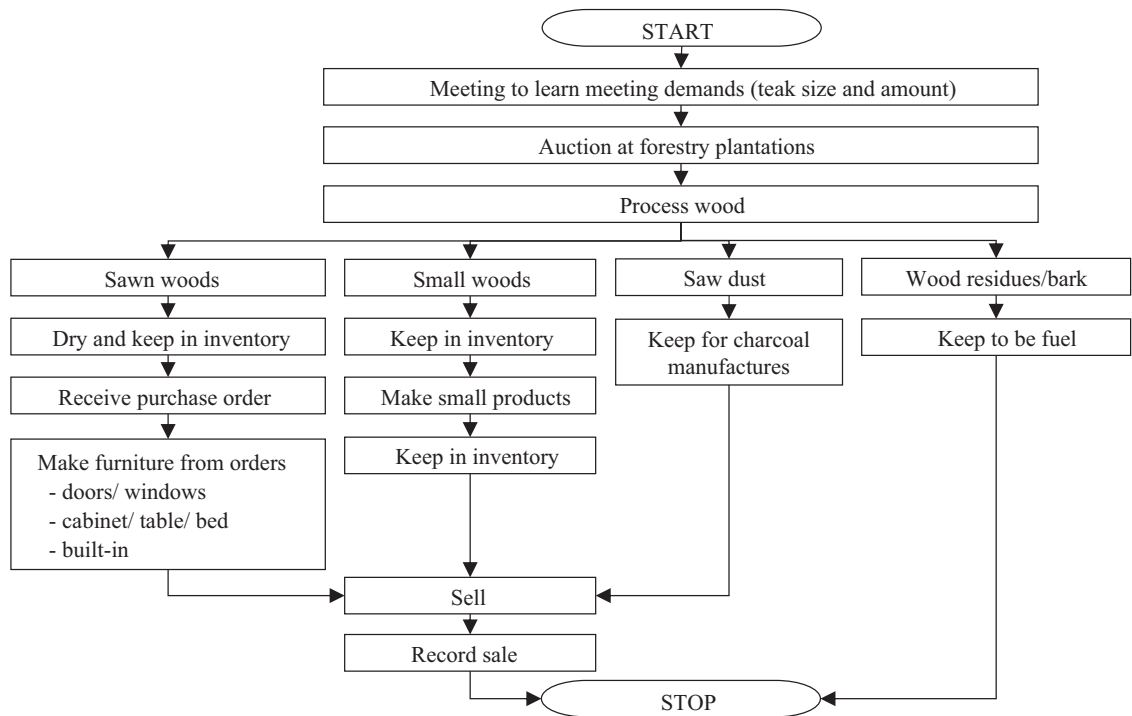


Figure 8 Teak processing procedure of sawmills



**Figure 9** Operation process of cooperatives

*Forestry plantations*

The study of cost of logistics and supply chain management of forestry plantation was a cost analysis of an average operation cost of six forestry plantations in Phrae province: Kun Mae Kham Mi, Mae Khampong-Mae Sai plantation, Napoon plantation, Mae Saroy plantation, Wang Chin plantation, and Mae Haad plantation by studying cost of operations in marking, felling-bucking, skidding to checkpoint, skidding to log landings, processing, and inventorying in B.E. 2560, which was compiled by the FIO in Phrae. Details are shown in Table 1.

Annual operation costs of B.E. 2560 of the six forestry plantations in Phrae province: Kun Mae Kham Mi, Mae Khampong-Mae Sai, Napoon, Mae Saroy, Wang Chin, and Mae Haad yielded the average operation cost of the entire process of 1,070 baht per cubic meter.

*Sawmills of the forest industry organization of Phrae Province*

The study of cost of logistics and supply chain management in the FIO sawmills in Phrae province is a cost analysis from the average operation cost of the entire teak processing procedure in the year B.E. 2559; from selecting wood quality, breaking down sawing, rough

cutting, specific-size cutting, grading, counting, drying, and inventorying. The total operation cost was 643.98 baht per cubic foot.

*Part 5 Stakeholders in Teak Product Industry*

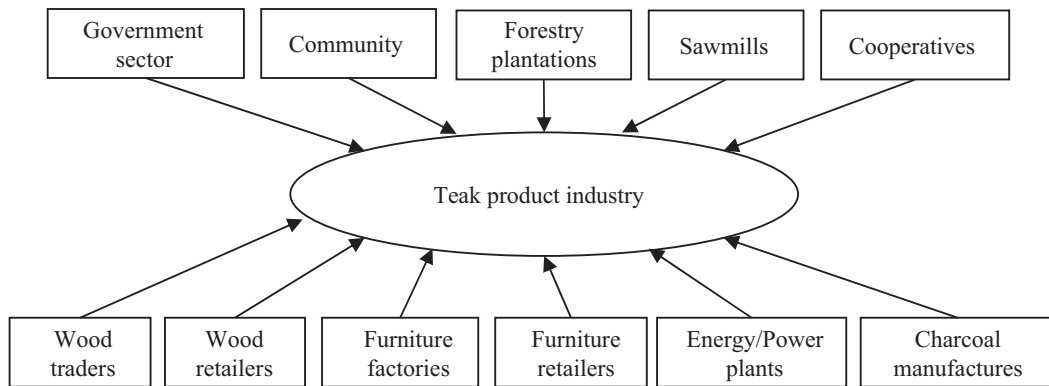
Stakeholders in teak product industry in Phrae province are government sector, community, forestry plantations, sawmills, cooperatives, wood traders, wood retailers, furniture factories, furniture retailers, energy companies or power plants, and charcoal manufacturers as shown in the following Figure 10.

The Government sector is the main stakeholder which legislates, controls, and inspects laws, regulations, and rules that all related parties would use and follow strictly. Community or general public living around forestry plantations most clearly receive benefit and effect from growing and cutting forestry plantations. This study inquired from people living around the forestry plantations and found that there was no strong effect from growing and cutting forestry plantations. There might be a small effect on the environment, but forestry plantations took good care of the people. In addition, some people could even earn a living from teak product industry.

**Table 1** Details of operation cost of the entire process of forestry plantations in Phrae province

Forestry Plantations	Marking (Baht/Cubic meter)	Felling- Bucking (Baht/Cubic meter)	Skidding to checkpoint (Baht/Cubic meter)	Skidding to log landings and piling (Baht/Cubic Meter)	Processing and inspecting (Baht/Cubic Meter)	Inventorying (Baht/Cubic Meter)	Total cost (Baht/Cubic Meter)
Kun Mae Kham Mi*	20	150	380	360	160	20	1,090
Mae Khampong-Mae Sai	20	150	360	360	160	20	1,070
Napoon	20	150	360	340	160	20	1,050
Mae Saroy	20	150	370	340	160	20	1,060
Wang Chin**	20	150	360	340	160	20	1,050
Mae Haad	20	150	390	360	160	20	1,100
Average							1,070

Note: \* Average cost in B.E. 2522 and B.E. 2527; \*\* Average cost in B.E. 2522 and B.E. 2533



**Figure 10** Stakeholders in teak product industry in Phrae province

Forestry plantation is the beginning producer with direct relation to teak product industry. The process from growing to auction or sale can affect stakeholders in teak product industry, such as environmental impact to surrounding communities, teak production quality to further use in sawmills, cooperatives, wood retailers, wood traders, furniture factories, or furniture retailers, as well as strict compliance to laws, regulations, and rules. Similarly, Sawmills, a direct stakeholder of teak product industry, are the main producers in the middle of the supply chain, buying logs from forestry plantations and processing them into various products such as sawn woods, interlocking woods, and furniture. Moreover, Cooperatives are the primary and secondary producer in the supply chain of teak product industry with duties similar to that of sawmills, but with smaller operation and mostly process teak to sawn woods or small teak products.

Wood traders are a producer at the end of the teak product industry, and are responsible for processing teak to sawn woods and selling to the general public for further use while monitoring environmental impact from processing procedure. Major wood traders can also create jobs in the teak product industry. Wood retailers are the primary and secondary producers in the middle of the teak product industry supply chain similar to cooperatives, but without collaboration in the form of cooperatives and mostly process teak to sawn woods or small teak products.

Large furniture factories are secondary producer at the middle of the supply chain, while small furniture factories are secondary producer at the last level in the supply chain. Both are responsible for processing teak to furniture and then selling to the general public while monitoring environmental impact from processing procedure. Moreover, furniture factories also create jobs



in the area. Furniture retailers are a producer at the end of the teak product industry, responsible for processing teak to furniture and selling to the general public. They need to strictly comply with laws, regulations, and rules when processing and selling teak products as well as monitoring environmental impact from processing procedure. Moreover, they also create jobs for people in the surrounding community.

Energy companies or power plants buy sawdust from sawmill processing production process to be raw material to make fuel or generate electricity, which helps reduce production waste from teak product industry and makes good use of sawdust. Energy companies/power plants also hire people in the surrounding communities. Finally, Charcoal manufacturers buy sawdust from cooperatives

or retailers to make charcoal to sell as raw material for fueling factories or the general public. This helps reduce sawdust and wood residue from teak processing procedure and also creates jobs for people in the surrounding communities.

*Part 6 Problems and Solutions in Logistics System and Supply Chain of Teak Product Industry*

Problems in logistics system and supply chain of teak product industry are caused by stakeholders in teak product industry in the form of policies, rules and regulations or operation procedure of logistics and supply chain of teak product industry as summarized in Table 2.

**Table 2** Problems and solutions in teak product industry

Minor Problems	Solutions	Related parties
Major Problems: 1. Logistics system and supply chain: Teak product flow		
1.1 Old and outdated policies	- Analyze operation process in all parties related to teak product industry to revise laws, regulations, and rules to be suitable, precise, and updated	- Government sector
1.2 Lacking clear laws on moving wood tips or residues from forestry plantations or processing wood residues to sawdust at forestry plantations		- Forestry plantations
1.3 Laws regarding transporting on public road or highways not facilitating teak product transports		- Sawmills - Communities - Wood traders - Furniture factories - Furniture retailers - Energy companies - Power plants - Charcoal manufacturers
1.4 Complicated verification of stump number, tree number, and logs	- Should use technology such as RFID or QR code to specify stump number, tree number, and logs for easy verification and inspection	- Forestry plantations
1.5 Lacking processing technology of wood tips and residues in forestry plantations for sale	- Develop technology to support wood tip and residue processing in forestry plantations, skidding logs in the forestry plantations, and loading logs to truck for transport, such as creating robots to move or mechanical arm to load logs onto truck - Should develop technology with practical use in forestry plantations, flexible and suitable for various conditions of forestry plantations, and with worthwhile cost - Should be developed by government sector for countrywide implementation with worthwhile investment and widespread use with economical and justifiable price	- Government sector
1.6 Lacking development in transporting technology with machinery to save costs		- Forestry plantations

**Table 2** Continued

Minor Problems	Solutions	Related parties
1.7 Complication and complexity in getting permission to transport teak products	- Should analyze and design proper, clear, and simple permission process to prevent duplicated step and reduce complication and complexity	- Government sector - Forestry plantations - Sawmills
1.8 Duplication in payment or process in getting permission to transport teak products, such as duplicated taxes	- Should analyze and design clear and simple fees and taxes payment, especially that of private sawmills who pay duplicated and multiple fees and taxes	- Government sector - Forestry plantations - Sawmills
Major Problems: 2. Logistics system and supply chain: Information Flow		
2.1 Lacking efficient coordination and data transmission within the supply chain	- Should develop application programs to transmit data within the supply chain	- Government sector - Forestry plantations - Sawmills
2.2 Duplication in permission document with various agencies for approval, i.e. submitting a similar document to different agencies	- Should analyze and design proper, clear, and simple permission process to prevent duplicated step and reduce complication and complexity	- Government sector - Forestry plantations
2.3 Multiple and duplicated steps in getting permission are very time-consuming	- Should develop Information Technology system to help the information flow be convenient, fast, correct, accurate, verifiable, and reduce papers	- Government sector - Forestry plantations
2.4 Wood accounting system is outdated, particularly related equipment which is hard to find in the market, and has no real-time connection	- Should develop and improve accounting system to be updated and connected online for data storage, verification, and control from anywhere and at anytime	- Government sector - Forestry plantations
Major Problems: 3. Logistics system and supply chain: Communities		
3.1 Lack of understanding in forming cooperatives. At present auctions are done by cooperatives, but process wood individually, which makes them unable to reduce production cost of teak products	- Government sector should educate and clearly explain about forming cooperatives as well as cost reduction and production efficiency improvement under cooperatives	- Communities - Cooperatives
3.2 Communities and private companies reduced growing forestry plantations, which may affect the amount of teak in the future and employment in the areas	- Government sector should promote and support growing replacement in forestry plantations in the system in form of policies or some investments such as teak saplings	- Government sector - Forestry plantations - Communities
Major Problems: 4. Logistics system and supply chain: Teak product value addition		
4.1 Lack of processing technology for small producers	- Should study and develop various teak product processing technology and at low cost for small producers to add value of teak products	- Government sector - Wood retailers - Furniture retailers
4.2 Lack of understanding and true demand of teak product market	- Should have intensive, academic-based market research on demand pattern of teak products to develop suitable products to meet the market demand and add value to teak products	- Government sector - Sawmills - Communities - Wood traders - Furniture factories - Furniture retailers

**Table 2** Continued

Minor Problems	Solutions	Related parties
4.3 Lack of research and development of different types of teak products, e.g. sawmills mostly sell sawn woods	- Should have research and development for various teak products that meet the market demand to offer choices to the market and add value to teak products	- Government sector - Sawmills - Communities - Wood traders - Furniture factories - Furniture retailers
4.4 Having middleman system to buy logs from general public and resell to sawmills underpricing the general public	- Should set up middleman system by government sector or sawmills such as arranging buying schedule at forestry plantations of general public to save transportation cost or encourage selling in group to add log values	- Government sector - Sawmills - Communities

## Discussion and Conclusion

There are two aspects of the study of supply chain structure: teak wood users and teak wood products. Teak wood users are forestry plantations, sawmills, cooperatives, wood traders, furniture factories, wood retailers, furniture retailers, energy companies/power plants, charcoal manufacturers, and the general public. Teak wood products include teak trees, stems, wood tips/branches, logs, unqualified logs, sawn woods, interlocking woods, furniture, small teak products, sawdust, and wood residues. The study of operation process of supply chain structure covers three parts: (1) Forestry plantations: to understand operation process, auction procedure, and direct sale of teak; (2) Sawmills: to understand communication process with forestry plantations to deliver wood and operations and processing procedure; (3) Cooperatives of communities in Phrae province: to learn overall operation process of cooperatives. The result of this study was similar to Prommontree (2013), who found that the supply chain management of the Parawood industry consisted of upstream (transportation, inspection and storage of materials from rubber plantations, middleman, or sawmills), middle stream (Parawood manufacturers) and downstream (inspection storage timber processing and deliver to customers).

The study of problems and improvement recommendations of logistics system and supply chain of teak product industry showed that: for physical flow of teak products, the policy and the law were main problems, and required analysis and adjustment of the laws, regulations, and rules to be suitable, precise, and up-to-date; for track and trace, it was complicated to track and trace logging, wood tip and residue processing, and machinery, and required new innovation and technology

to support; for information flow, the main problems were lacking coordinated system, duplicated document operation, and outdated accounting system, which required analysis, design, and development in information system to improve performance; for community problem, the major point was the misunderstanding in the collaboration of people to be cooperatives for teak lumbering, and doubt of private sector to invest in forestry plantations, which required the government sector to educate and create measures to build confidence; for value addition of teak products, the lack of processing technology for small producers, true understanding of market demand, research to develop various products, and underpricing from the middleman, required collaboration between public and private sectors to solve overall problems. Likewise, Prommayanon et al. (2019) found that the primary activities are based on the value chain concept of produce on logs in forestry plantation, including raw material, production and operation, transportation, marketing and sales, customer service. The main supporting activities are technology development and procurement. However, for more thorough study of the logistics system, there should be further study in the following topics:

1. This study only covers forestry plantations under the Forest Industry Organization. From interviews with wood buyers, there are also private forestry plantations in Phrae province. Additional study in such plantations may show different structure of logistics system, cost, and problems, because teak wood is in a prohibited wood list, which has complicated operation, especially in getting approval.

2. Study sites are only forestry plantations in Phrae province. Additional study in other areas which may have different results, is recommended.

**Conflict of Interest**

There is no conflict of interest.

**Acknowledgements**

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