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INTERNATIONAL BAMBOO AND RATTAN ORGANISATION



Bamboo Value Chain Analysis in Thailand

THAILAND ENVIRONMENT INSTITUTE

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PUBLISH	September 2021	

PREFACE

Thailand became a member of the International Network for Bamboo and Rattan (INBAR) since 2016 with the Royal Forestry Department (RFD) as the Focal Point Representative for Thailand. RFD has prepared a Draft National Bamboo and Rattan Resource Management Master Plan (2018-2036) however; there are important gaps in the draft plan which are information on bamboo resources and the market chain in the country which are not enough. Thus, analysis of the bamboo value chain was initiated to clarify the roles and responsibilities of each of the relevant agencies at every level. Other than this, the analysis of the bamboo value chain also helped to identify the strengths, weaknesses, opportunities and limitations for every value chain for bamboo. In addition, this information will help to design the strategies and work plan which contributes towards the target in promoting bamboo as an economic specie to assist in elevating the quality of life of local people and sustainably manage bamboo resources as well as lead towards recommendations for future developments.

Hence the preparation of this Bamboo value chain analysis in Thailand research report is necessary in order to move towards management and utilization of bamboo resources for social and economic development as well as environmental conservation. Thailand will highly benefit if there is a clear management framework and guidelines for bamboo resource development so that bamboo related issues can move forward in the same direction and lead to sustainable promotion and income generation for local people and Thailand in the future.

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EXECUTIVE SUMMARY

Bamboo has been utilized as part of the way of life of the Thai people since the past whether they are used for food, medicine, clothing, accommodation, social power, knowledge or cultural purposes. Therefore, bamboo is an interesting plant to use and increase value by processing it into various kind of products to create jobs and income for the community.

Around 1,500 species from 80-90 genera of bamboo were found in the world. In Thailand, there are about 69 species from 17 genera scattered throughout the country. About 27 species are found in the forest area, the most common of which are *Thyrsostachys siamensis* followed by *Dendrocalamus membranaceus* and *Gigantoochloa albociliata,* respectively. The Northern Region has the highest number of bamboo species followed by the Central Region, Northeastern Region and Southern Region. Meanwhile, there are areas where bamboo is grown for commercial purposes scattered throughout the country. The largest bamboo plantation is in the Eastern Region with an approximate area of 64 km^2 (40,000 rai) followed by the North,

Central, North Eastern and Southern regions respectively. Production of bamboo products and utilization of processed bamboo products has a long history in the country. Bamboo has been processed into products to generate income for the community. Some types of products are in demand in both Thai and Foreign markets. At the present there is high competition in the bamboo trade business. In 2020 there were 296 producers of bamboo products for their One Tambon One Product (OTOP) project. Community Enterprises are mostly scattered in the North Eastern region whereas the entrepreneurs and factories are scattered in the North.

Export of bamboo and bamboo products from Thailand can be classified into non-processed bamboo which is exported as bamboo pole and processed bamboo such as bamboo plywood, wicker and preserved bamboo shoots, etc. The export information of processed bamboo for 2015 – 2019 found that the total export value of bamboo increased since 2015. Products from bamboo can be categorized into 7 groups based on the export value from most to least in 2019 as 1) Food products, 2) Non-processed bamboo timber, 3) Processed bamboo timber, 4) Furniture, 5) Wicker products, 6) Bamboo tissue products, and 7) Bamboo charcoal products which totals to 586.25 million THB. At the same time the value of import of bamboo products from other countries in the wicker product group, bamboo tissue, processed bamboo and bamboo charcoal has the tendency to decrease while the food and processed bamboo timber has an increasing import value. The import value listed from most to least in 2019 is 1) Food products, 2) Processed bamboo timber, 3) Furniture products, 4) non-processed bamboo timber, 5) Bamboo tissue products, 6) Wicker products, and 7) Bamboo charcoal. However, there is the need to have guidelines for product development and product processing so that they are produced according to the market demands. Also, technology development is necessary so that the products produced have good quality comparable to other countries, especially with the competitor country that has high production potential such as China, Vietnam, Japan, India and Myanmar.

Plantation and utilization of bamboo should be promoted to the agriculturalists so that there are enough bamboo resources to supply for the future market needs. Creating added value and taking a share in the bamboo value chain throughout the value chain is associated with the work of many sectors. This includes bamboo sapling, bamboo shoots, culm, bamboo plywood and high-quality bamboo charcoal. The analysis results of the bamboo value chain in Thailand can be summarized as follows.

Bamboo sapling: The production of bamboo sapling consists of the cost of sapling, chicken manure fertilizer, water, care-taking and management of the bamboo plantation, and the cost of labor for implementing various activities such as pruning and digging up the stump, etc. The farmers that produce bamboo saplings will have income starting from the second year onwards. Bamboo sapling production have cost of investment consisting of the sapling, chicken manure fertilizer, water, care-taking and organizing the bamboo plantation. The labor cost for the activities and operations includes pruning, digging out stumps, etc. Bamboo sapling producers will generate income starting from the 2nd year onwards. The growth rate of the bamboo sapling depends on the care-taking process and management of the bamboo plantation of the farmers. The price of *Dendrocalamus* spp. (local name: Pai Sangmon) sapling at the plantation is 40 THB/sapling for wholesale and 40-120 THB for individual saplings. Whereas the sapling for *Bambusa* sp. is 12 THB/sapling for wholesale and 25 THB for individual saplings. Other than that, the growing of bamboo sapling must consider the trend and type of bamboo that is in market demand and also the local geography. This is because each investment will give a return after 2 years of investment. However, the production of bamboo sapling requires small area but provides quite high return depending on the type or species that is in trend at the specific time.

Bamboo shoots: The production of bamboo to harvest bamboo shoots have investment costs consisting of the cost of sapling, chicken manure fertilizer, water, labor, care-taking and management of the bamboo plantation such as weeding and cost of culms thinning, etc. The farmers will gain income from bamboo shoots from the 3rd year onwards. During

the bamboo shoots season, it can be sold at 5 THB/kg but during out-of season the price is 30 THB/kg Other than this, the bamboo shoots can be processed into pickled bamboo shoots to increase its value to as high as 70 THB/kg However, the price of in-season bamboo shoots is very low and there should be additional livelihood skills enhancement for the farmers to add value to their bamboo shoots by processing it into other products. This should include supporting and promoting the farmers to produce out-of season bamboo shoots and select the type of bamboo shoots according to market demand. This will help to increase the sales for the farmers.

Bamboo culm: The production of bamboo culm has investment costs consisting of the cost of sapling, chicken manure fertilizer and labor cost in the whole operation. For this process if the farmers can cultivate their own sapling, they will be able to reduce the cost of the sapling. On this note, the phase during years 1 – 3 of bamboo cultivation will not generate income for the farmers from selling of the culm but income can be gained from thinning culms and bamboo shoots. The price of bamboo culms depends on the species that are in demand in the market, the size of the culm, the diameter and the price negotiated between the farmers and the buyer. However, there should be capacity building activities to support the farmers so to equip them with knowledge

on growing and managing to be able to increase the selling value as well as knowledge in selecting proper specie to be planted in the locality.

Bamboo plywood: The production of bamboo plywood is the process of processing bamboo for construction purposes. Bamboo raw materials must always be stocked in the factory to prepare for production. The production process of bamboo plywood has quite high investment cost which consists of the costs for chemicals used in the timber protection process, labor and transportation, etc. There are also initial investment cost of management and marketing and other than this, the cost of operating machinery and equipment in the establishment of a factory. A piece of 1-layer bamboo plywood can be sold at 1,650 THB whereas 3-layers bamboo plywood can be sold at 2,850 THB. The trend of demand for bamboo plywood in Thailand is consistently rising, especially in the furniture industry that has to import wood from abroad as raw materials due to the insufficient raw material of wood to be used in the production process. Therefore, bamboo plywood production is one way to replace other types of plywood.

Quality Bamboo Charcoal: The bamboo culm that is most appropriate for making quality bamboo charcoal should come from whole culm at the age of 3 years or more. The main investment cost of production of quality bamboo charcoal is the kiln. This will make such high quality bamboo charcoal which is in demand in the market. The initial cost of a charcoal kiln is as high as 1 million THB but if well maintained it can be in service for as long as 20 years. At present, the production of quality bamboo charcoal in Thailand is quite low. Therefore, knowledge should be raised for farmers or entrepreneurs to be able to produce quality bamboo charcoal that is in demand in the world market. It will also add value to the bamboo in Thailand as well and increase the income for the farmers that produces charcoal from bamboo. It will also enable the quality bamboo charcoal to be used for other benefits such as for medicinal purposes, cosmetics, health products, etc. In general, most bamboo producers sell bamboo culms to factories for processing into products. The production of bamboo charcoal is another way to increase the value to bamboo and increase the investment return. In future, if bamboo is driven to be the country's economic crop, it will reduce the import of bamboo from foreign markets and create sustainable and cost-effective utilization of bamboo resources.

The study of the bamboo value chain in Thailand started from the import of the production materials to operational process, marketing, until after sales service. A workshop was organized to present and exchange opinions on the results of the study and analyze strategies for sustainable drive of bamboo resources. The results of the meeting can be compiled into four policy proposals as follows:

(1) Creating an enabling environment for the production and trade to clearly support and promote the processes throughout the bamboo value chain in Thailand. This can be carried out by improving relevant laws to facilitate the use of bamboo in different types of forest areas. along with promoting the utilization and processing of bamboo products to be on par with other economic crops. There should be a main organization that manages bamboo resources at the national level and also engage the private sector in the implementation to create a sustainable market mechanism for the mobilization of bamboo in the market.

(2) Creating understanding of bamboo management for increasing production by disseminating knowledge on how to select the proper species that suitable for the area, the species that popular and marketable. Take into account the selection of bamboo parts that are suitable for various products. Farmers should also be encouraged to grow other types of crops together with the bamboo (mixed crops) in the plantation to generate income during the first 3 years.

(3) Promoting marketing and trade to upgrade bamboo to be an important economic crop of the country. There should be a specific working unit that determines the middle price and the central market for selling and buying of bamboo saplings and bamboo culm in the country. Small and Medium Agricultural Enterprises (SMAEs) should be promoted and market management skills should be provided for the group in order for them to further develop and top up on the implementation efficiently.

(4) Support research and studies on the conservation and utilization of bamboo resources with emphasis on continuous research and studies that can be scaled up commercially. Promote and support the private sector in competing and developing technology, production innovation and bamboo product processing as well as supporting technology and production innovations to increase the value of bamboo products with environmentally friendly. Set up a research and development unit for bamboo-based innovations and disseminate the knowledge from the researches and studies to the farmers and small scaled entrepreneurs. Developing of high-value product production models that meet the needs of both domestic and international markets.

1 INTRODUCTION

1.1 Rationale and Justification

Bamboo is a native plat that can be grown and widely distributed. It has long been a resource related to human daily life and has been used for a variety of purposes such as ecology, economy, society and culture. Moreover, bamboo is a fast-growing plant that suitable for planting to restore the ecosystem due to its broad root system and dense canopy which is important in helping to increase the efficiency of soil and water conservation as well as help prevent erosion of the soil along the riverbank.

Thailand became a member of the International Network for Bamboo and Rattan (INBAR) since 2016 with the Royal Forestry Department (RFD) as the designated Focal Point for the country. As the Focal Point, the RFD has initiated and developed a Draft Master Plan for National Bamboo and Rattan Resources Management (2018-2036) with the objectives to manage and utilize bamboo and rattan resources to support social and economic development and protect and conserve the environment. Thailand will highly benefit if there is a clear management and implementation framework for the development of bamboo and rattan resources. However, in the development process (drafting) of the Thailand Master Plan, there is an important gap which is the information on bamboo production and marketing chain that is not enough.

Therefore, bamboo value chain analysis will establish the roles and responsibilities of all relevant departments and has a comprehensive policy related to the product development process. Meanwhile, there is a policy that completely involves the process of product development. It also provides an insight into the opportunities and limitations for all bamboo value chains, and the information will be critical to strategy design and plans to achieve the goal of promoting bamboo as an economic crop to improve the quality of life of local communities and sustainable bamboo management. This leads to suggestions for further development in the future.

1.2 Objectives

1) To analyze the value chain of bamboo, potential of using bamboo in creating social and economic development and environmental conservation practices.
2) To specify the policy recommendations for the sustainable development and management of bamboo resources.
3) To provide information to disseminate knowledge on sustainable use of bamboo resources.

1.3 Process and methodology

The study and analysis of the value chain of bamboo in Thailand consists of the following processes and methodology as described in the following activities.

Research study, collect and analyze data on bamboo resources, in this process secondary data from documents and reports are used to accumulate information on the policies and plans that are relevant to the bamboo resources and the economic information and statistics relevant to bamboo resource. The information is then analyzed in terms of bamboo resources and the Thai and global market trends. In-depth interviews with the bamboo farmers were also carried out.

Analysis of the bamboo value chain and the potential in bringing bamboo into the social and economic development aspect was carried out by performing analysis on the information on the bamboo resources and information and statistics of bamboo for the bamboo value chain in Thailand. The analysis was also performed on the potential of using bamboo in the social and economic development process.

Workshops for exchanges of the research results and analysis of the sustainable policy recommendations for bamboo resources are workshops held to present the findings from the research studies and analyze the policy recommendations for making a sustainable bamboo resources development and promotion plan for Thailand.

Prepare knowledge dissemination documents for utilization of bamboo resources and market potential under the sustainable development principles. This is to disseminate knowledge to the relevant sectors, the entrepreneurs who produces and processes bamboo-based products and agriculturalists who grow bamboo so that they are aware of the potential of the bamboo market in Thailand and the benefits of bamboo in sustainably develop social, economic and environment aspects into the future.

Prepare a complete analysis report of the bamboo value chain for Thailand by collecting ideas and suggestions from the workshops and incorporating them into the final report to make changes that will present sustainable policy recommendations for Thailand in creating a sustainable national development and promotion plan for bamboo resources utilization.

2

BAMBOO RESOURCES IN THAILAND

Bamboo is a local resource that is valuable to the way of life of Thai people from the past to the present. This is because bamboo is a fast-growing plant and is a multipurpose specie which can be used from its rhizome/roots, clumps, shoots, leaves, leaf sheath, branch, and culm. Also, it can produce more oxygen than other types of plants which can be up to 35% or more and can absorb carbon dioxide which is the important factor for the GHG effect (The north, 2019). There are many types of bamboo in Thailand due to the environment that allows bamboo to grow and therefore can be found in all region of the country. For Thailand bamboo is used both directly and processed into various products. Bamboo is relevant to the ways of life of Thai people in terms of food and medicine, clothing, accommodation, furniture, equipment, energy and environment, society, local wisdom and culture.

2.1 Bamboo resources in Thailand

There are many species of bamboo; approximately 80-90 genera worldwide with about 1,500 species. In Thailand there is approximately 69 species from 17 genera which are found scattered in different areas as follows.

Distribution of bamboo in the forest area: The study on bamboo resource survey in the forest area by the office of Protected Area Rehabilitation and Development of the Department of National Parks, Wildlife and Plants Conservation (2012) using consistency random sampling method in 2011 found that there are 27 species of bamboo in the typical forest area and the species most found was *Thyrsostachys siamensis* followed by *Dendrocalamus membranaceus* and *Gigantoochloa albociliata* respectively. They scattered throughout all regions of Thailand. Most of bamboo is found in the North followed by the Central, Northeastern and Southern regions respectively. In terms of density the area with the highest density of bamboo is the Central region followed by the Northeastern, Northern and Southern regions respectively as shown in Table 1.

Table 1 Estimated Number and Density of Bamboo in Thailand by Region (Survey data 2011)

Region of Thailand	Forest Area (rai)	Estimated Number of Bamboo		Density	
		million clump	million pole	clump /rai	pole/rai
Northern	56,283,271.49	1,012.58	11,764.75	16.27	190.14
Northeastern	15,813,844.52	311.53	3,897.44	18.57	232.51
Central	18,846,764.53	412.29	6,148.65	21.36	319.40
Southern	9,911,717.95	57.94	990.42	5.69	97.24
total	**100,855,598.50**	**1,794.35**	**22,801.27**	**16.56**	**207.00**

Source: Department of National Parks, Wildlife and Plant Life (2012)

Distribution of bamboo in the bamboo plantations: The study on bamboo growing in Thailand (Department of Land Development, 2020) found that the commercial bamboo cultivation areas are scattered throughout the country, amounting to 91,746 rai. (approx. 146.79 km^2). It was found that the Eastern region had the most planting area of 40,364 rai (approx. 64.58 km^2) followed by the North of 21,680 rai (approx. 34.69 km^2), Central region of 14,808 rai (approx. 23.69 km^2), Northeastern region of 14,410 rai (approx. 23.06 km^2) and lastly the Southern region with the least bamboo plantation area of 484 rai (approx. 0.77 km^2) as shown in Figure 1. The type of bamboo that is popularly grown in Thailand is Pai Sang Mon (*Dendrocalamus* spp.), Pai Kimsung (*Bambusa beecheyana*), Pai Tong (*Dendrocalamus asper*), Pai Leang (*Bambusa* sp.), and Pai Ruak (*Thyrsostachys siamensis*). Prachin Buri province is the province with the most commercial bamboo plantations in Thailand. Statistics on the cultivation of bamboo from the Provincial Agricultural Office in Prachin Buri province (2019) found that during 2018-2019 Prachin Buri province had the highest area for *Dendrocalamus Asper* Backer plantation which is approximately 31,061 rai (49.70 km^2) composed of a cultivation area of 17,877 rai (28.60 km^2). The shoot production per rai is 5,959 kg/rai (3,724,375 kg/ km^2). However, bamboo cultivation in Thailand is still limited, namely the lack of promotion and development of cultivation methods for farmers and there is little care given in management of bamboo planation. As a result, the quality of bamboo does not meet the market demand and the factories demand which uses bamboo as their raw material for furniture or other products.

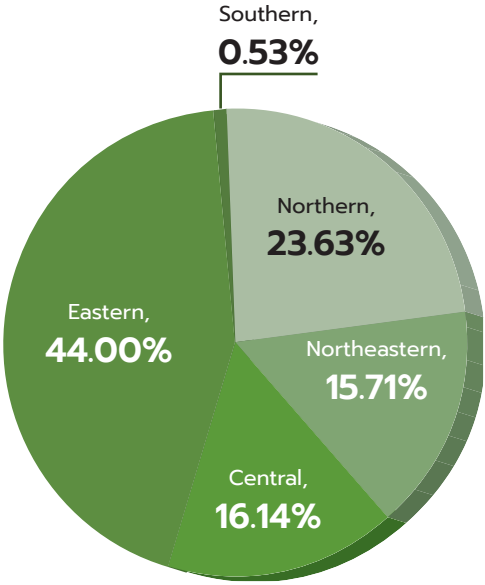

Figure 1 The proportion of area under bamboo cultivation in various regions of the country.

Source: Land Development Department (2020)

2.2 Diversity and utilization of bamboo in Thailand

The diversity of bamboo species that is popularly grown in Thailand based on the species collection from many sources found that there are 69 species from 17 genera. More than 50 species from 13 genera are native to Thailand. The 19 species of 5 genera are imported for the production of bamboo shoots and ornamental purpose. Diversity of bamboo can be divided according to their use as follows:

- **Bamboo shoots as food** include *Dendrocalamus* spp., *Bambusa burmanica*, *Dendrocalamus brandisii*, *Dendrocalamus asper*, *Thyrsostachys siamensis*, *Bambusa* sp., *Dendrocalamus giganteus*, and *Dendrocalamus hamiltonii*.
- **For construction** such as *Bambusa bambos*, *Dendrocalamus* spp., *Thyrsostachys siamensis* and *Bambusa* sp.

- **For furniture industry** such as *Dendrocalamus* spp., *Dendrocalamus aspere*, *Dendrocalamus hamiltonii*, *Thyrsostachys siamensis* and *Bambusa* sp.
- **For the wicker and crafts industry** such as *Bambusa nutans*, *Gigantochloa albociliata*, and *Dendrocalamus sericeus*.
- **For pulp and paper industry** such as *Dendrocalamus asper* and *D. membranaceus*.
- **For ornamental plants** such as *Bambusa lako*, *Pseudosasa japonica*, *Schizostachyum brachycladum* and *Bambusa vulgaris*.
- **For boundary line or wind breakers** such as *Thyrsostachys siamensis* and *Bambusa* sp.
- **For sweetened glutinous rice in bamboo** such as *Cephalostachyum pergracile* and *Bambusa bambos*.
- **For medicinal purposes** such as *Bambusa bambos*, *Thyrsostachys siamensis*, *Bambusa lako*, *Vietnamosasa pusilla*, and *Dinochloa scandens*.

This shows that there are many species of bamboos in Thailand, both native species and imported species for trade and commercial purposes. Many of the bamboo species grow well in Thailand because the climate and geographical terrain in Thailand is compatible and supports its growth. Therefore, it is an advantage for the country to develop as a source of bamboo for the world economy in the future.

The utilization of bamboo in Thailand can be categorized into categories consisting of food and medicine, clothing, accommodation, furniture and utility products, energy and environment, and social, wisdom and cultural category. The details of the utilization are as follows.

- **Food:** Bamboo is a plant that is widely used for food because it is rich in nutrients and minerals that are beneficial to the body (Highland Research and Development Institute (Public Organization), 2017). The part that is used for food is the bamboo shoot. Thailand produces large amounts of bamboo shoots in the raining season. Therefore, farmers who have good water management system will result in good supply of bamboo shoots for consumption and can be sold all year round.

- **Medicine:** Bamboo is beneficial for the body and can cure many diseases. At present, bamboo are processed into various kind of products for value added. The parts of bamboo that can be used for medicinal purposes such as the shoots can be boiled for medicinal purposes, while research has shown that bamboo leaves contain antioxidant flavonoids glycosides that help reduce the risk of alzheimer's disease, diabetes, cerebrovascular disease (blood clotting in the brain), and etc. On the other hand, the bamboo culm can cure stomach ache and the bamboo roots can be used to cure Dermatophytosis or Ringworm as well as boiled and drink as diuretics.
- **Clothing:** Bamboo is a plat that has long fibers and is highly porous therefore it can absorb moisture well and is appropriate for developing into textiles and garments, lady's purses, hats, etc. Other than this, the fibers from bamboo can be mixed with carbon powder from bamboo charcoal to make synthetic fiber that has good moisture absorption and ventilation properties.
- **Energy and Environment:** Bamboo is an alternative plant for renewable energy. This is because all parts of bamboo contain cellulose, which can be used as biomass and can produce renewable energy fuels. Other than this, it is a plant that has high

importance for the environment. Bamboo provides habitat for wildlife and act as a food source, help to hold the river bank and prevent soil erosion, and reduces the impact of storm winds. It also provides higher biomass per area than other crops in the same period and area. Therefore, it contributes to the absorption of carbon dioxide higher than ordinary trees.

Social, Wisdom and Culture: Thai people have known the use of bamboo since prehistoric times; hence bamboo is related in the applications of daily life in terms of local wisdom, ceremonial and customary activities. Bamboo has been used as processed food such as pickled bamboo shoots and dried bamboo shoots for consumption out of season. Meanwhile bamboo culm has been used as material for wicker and other daily utility equipment. In addition, Thai people have a relationship with the way of nature. and rely on natural resources for living which make bamboo become part of traditions, rituals and other traditional events such as the using of bamboo to make the flag for the Boon Maha Chat merit making ceremony, making lanterns in the Loy Kratong festival, and using it to decorate the boats or decorative lanterns in the Lai Rua Fai Merit Making Ceremony, etc. (Pratchaya Youngpattana and Rawee Thaworn, 2014).

It can be seen that Thailand has many species of bamboo, both the native species and the imported species that were imported for utilization from past to present. Bamboo is a plant that is used in everyday life including food, medicine, clothing, housing, energy and environment, and social, intellectual and cultural aspects. Bamboo is therefore an interesting plant to add value by processing it into various kind of products to create jobs and income for the community, especially the local communities whose way of life is most closely related to bamboo.

2.3 Marketing and Bamboo Trade

Thailand has been producing and using bamboo-based processed products for a long time. Thailand has been producing processed bamboo products to create income for the people in the community and some of the products are in market demand both in the Thai domestic market and in the international market. At present, the businesses and trade associate with bamboo is very competitive. From marketing information and trade in bamboo both domestically and internationally can be summarized as follows:

Domestic market

The Thai domestic market for bamboo and bamboo products can be categorized into the following categories including selling of bamboo shoots such as fresh bamboo shoots, steamed bamboo shoots and pickled bamboo shoots, selling of bamboo saplings, selling of bamboo culm both unprocessed and processed form and selling of value-added products from processed bamboo.

This study focused on studying and analyzing the utility of bamboo culm in both processed and unprocessed forms. For this, the domestic market in Thailand can be categorized based on the characteristics of the entrepreneurs in 3 categories which are

1) One Tambon One Product (OTOP) producers which is the group that selects a type of goods or an outstanding product from a sub-district and introduces it to the market (Community Development Department, 2019), 2) the Community Enterprise Group who produces goods which is an aggregation of people in the community to operate a business that have a formally registered Business Registration Certificate (Department of Agricultural Extension, 2020), and 3) factory operators who are entrepreneurs operating at the factory level and uses machines in producing and processing goods (Department of Industrial Works, 2020). There are entrepreneurs dealing with bamboo and bamboo products scattered throughout the country as shown in Table 2.

Table 2 Ratio of entrepreneurs related to bamboo products in Thailand in 2020

Region of Thailand	OTOP producers form bamboo (cases)	Community Enterprise Group form bamboo (cases)	Factory operators (cases)	
			Bamboo	Bamboo shoot
Northern	89	7	20	9
Northeastern	110	36	4	4
Central	78	12	5	5
Southern	19	3	0	0
Total	**296**	**58**	**29**	**18**

Source: [1] Community Development Department (2020)
[2] Department of Agricultural Extension (2021)
[3] Department of Industrial Works (2020)

For the bamboo trade in Thailand in 2020, the OTOP group has the highest number of producers at 296 entities. These producers choose to produce products that are in trend which include household furniture, wicker baskets, sticky rice containers, vases, furniture, lamps, fans, hats, bags, food baskets, cradle, blinds, and placemats, etc. It was found that most of OTOP producers are in the Northeastern region. Other than this, bamboo is used in other aspects such as processed into cosmetics, musical instruments, soap, shampoo, bamboo vinegar, teeth cleaning powder, deodorant charcoal, bamboo charcoal pillow, etc. While community enterprises are most distributed in the northeastern region, the factory operators are most distributed in the northern region.

From the report on Bamboo and the Ways of Life of Thai People, it was found that the requirements for bamboo in the country have increased. This includes the requirement for use of bamboo in the agricultural sector, aquaculture, and fishery and for reducing coastal erosion. At present, the export of bamboo from Thailand is less because the amount of bamboo for domestic use is almost not sufficient (Pratchaya

Yongpattana and Rawee Thaworn, 2014). In addition, the trend of domestic demand for plywood is increasing because the demands for plywood to replace natural wood has continued to expand, especially the furniture industry, which imports wood from abroad. Therefore, if we can promote the cultivation of bamboo to meet the needs of the domestic market, it will be a way to promote Thai bamboo market to grow and lead to the development of higher value products.

International markets

The export of bamboo and bamboo products of Thailand can be categorized into unprocessed bamboo (bamboo pole), and processed bamboo (bamboo plywood, wicker and preserved bamboo shoots, etc.). From the data on exports of processed bamboo products during 2015-2019, it was found that the total value of bamboo product exports tends to increase from 2015. The value of exports ranked from highest to lowest in 2019 are: 1) food products, 2) unprocessed bamboo, 3) processed bamboo products, 4) furniture, 5) wickers, 6) bamboo pulp and 7) bamboo charcoal with has a total value of 583.25 million THB (The Customs Department, 2020).

Figure 2 The export values from bamboo products in 2015-2019 (million THB

Source: The Customs Department (2020)

The trend of the expansion rate of the export value from bamboo products during 2015 – 2019 showed that the export values from 2015-2019 are 425.49, 567.85, 498.95, 571.94, and 587.16 million THB accordingly as shown in Figure 2. From this information it was found that the processed bamboo products had the highest expansion rate and followed by furniture, bamboo charcoal, bamboo pulp and food respectively as shown in Table 3.

Table 3 The export value of bamboo products during 2015-2019

Product	Export of bamboo products (million THB)					Expansion rate (2018-2019)
	2015	2016	2017	2018	2019	
food products	355.32	473.07	405.39	434.92	440.16	1.20
unprocessed bamboo	43.89	55.51	59.32	106.84	94.73	-11.33
processed bamboo products	3.13	4.3	16.61	17.28	36.34	110.30
furniture	0.00	0.00	8.79	4.09	7.32	78.89
wickers	21.85	33.87	7.98	7.28	6.74	-7.55
bamboo pulp	1.18	0.92	0.71	0.81	1.06	30.30
bamboo charcoal	0.12	0.17	0.15	0.72	0.81	12.50
total	**425.49**	**567.85**	**498.95**	**571.94**	**587.16**	**2.66**

Souce: The Customs Department (2020)

The value of imported bamboo products during 2015-2019 showed that the import value in the wicker group, bamboo pulp, non-processed bamboo and bamboo charcoal tend to decrease while the value for food products and processed bamboo has increased as shown in Figure 3. The total import value in 2015 was 229.57 million THB whereas in 2019 the total import value was 238.07 million THB. The food products were most imported from abroad, consisting of dried bamboo shoots, fresh bamboo shoots and vacuum-packed bamboo shoots, respectively. Second to the food products is the processed bamboo which includes plastwood, building construction materials from bamboo, mosaic floors, chopsticks, and other products, etc. From the data, they can be sorted by import value from highest to lowest in 2019 as follows: 1) food product 2) processed bamboo 3) furniture 4) non-processed bamboo 5) bamboo pulp 6) Wicker bamboo and 7) Bamboo charcoal, as shown in Table 4.

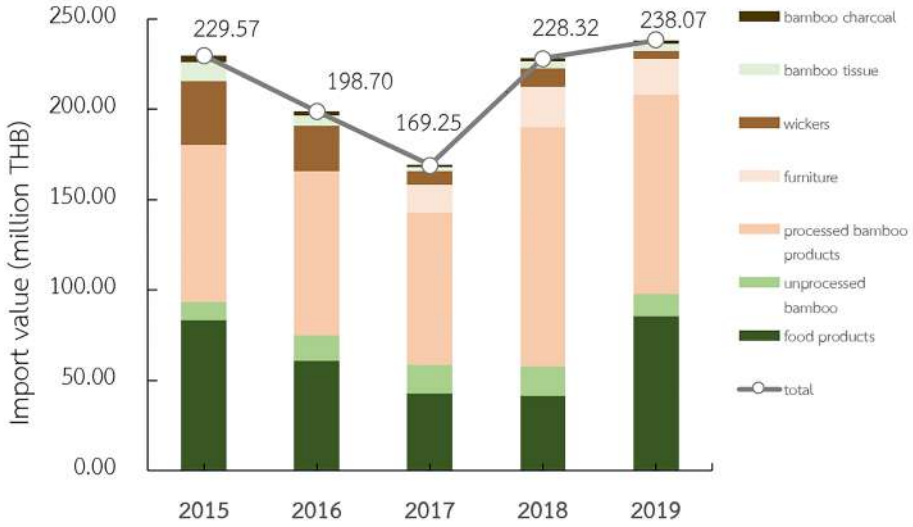

Figure 3 The import value of bamboo products during 2015–2019 (million THB)

Source: Customs Department (2020)

Table 4 The import value of bamboo product during 2015-2019

Product	Import of bamboo products (million THB)					Expansion rate (2018-2019)
	2015	2016	2017	2018	2019	
food products	83.45	60.71	42.62	41.61	85.53	105.55
unprocessed bamboo	10.17	14.31	16.21	16.31	12.49	-23.41
processed bamboo products	86.62	90.54	83.99	132.29	110.16	-16.73
furniture	0.00	0.00	15.56	22.14	19.67	-11.15
Wickers	35.18	25.31	7.17	10.45	4.38	-58.08
bamboo pulp	10.62	5.74	2.20	3.81	3.95	3.67
bamboo charcoal	3.53	2.09	1.51	1.72	1.89	9.88
total	**229.57**	**198.70**	**169.25**	**228.32**	**238.07**	**4.27**

Source: Customs Department (2020)

When comparing the value of export to the value of import of bamboo products it was found that from 2015-2019 the export value is 2.47 times more than the import value. It is visible that in 2019 Thailand's rate of export of bamboo products increased for both processed and non-processed bamboo products where the majority of the increase in export value came from the food products. At the same time the rate of import of bamboo products also increased where most of the products imported are processed bamboo. The major trading partners for bamboo products are Germany, Taiwan, the United States and Norway while the main competitors are China, Japan, Vietnam, Myanmar and Indonesia.

Global situation of bamboo import and export

The situation of bamboo and rattan imports and exports in 2018 found that China is a country with the largest import and export of bamboo and rattan in the world. It exports to Europe worth $540 million, or 24 percent of China's total bamboo and rattan exports followed by the USA, Japan, Taiwan, Viet Nam, India, Korea, Thailand and Canada respectively. China imports the most bamboo from Malaysia accounted for about $11.4 million, or 34 percent of China's imports followed by Vietnam, Indonesia, Philippines, Europe, Taiwan and Japan, respectively (INBAR, 2019).

In addition, the growth of the bamboo market and bamboo products has increased in volume. Especially the use of bamboo as a substitute for real wood. This has great benefits for environmentally conscious consumers and contributes to the government's idea of solving the problem of forest encroachment and raising awareness of the use of environmentally friendly materials. At the same time, it is in line with the industrial requirements for industries that use bamboo as their raw materials in the production process. This resulted in continuous growth of the bamboo market especially in the Asia Pacific region. The rate of exports to the USA, Germany, France and other countries has also increased. (Region And Segment Forecasts, 2019). Similarly, the industrial factories related to pulp and paper production requires bamboo as their raw material which is as high as 40% of all their raw materials. At present, China and Brazil are now the leaders in the region's market. India has an advantage in bamboo resources because there are many bamboo resources in the country (Future Market Insights, 2019).

It can be seen that the trend of bamboo and bamboo products export in Thailand tend to increase. However, neighboring countries such as China, Vietnam, Japan, India and Myanmar are also countries with high production potential. Therefore, there should be a way to develop our products and further process the bamboo products to produce them in such a way that creates market demands. Including the need to develop technology to make the quality of products on par with foreign countries together with the need to promote the cultivation and utilization of bamboo for farmers and interested parties in order to have enough bamboo resources to meet the market demand in the future.

3

ANALYSIS OF THE BAMBOO VALUE CHAIN IN THAILAND

Bamboo is being utilized more and more in the daily life. They are used as ornaments and decorations, as furniture to substitute the real wood such as chairs and tables, souvenirs, flooring materials, and plywood. The processing of bamboo products in Thailand is limited by production technology and lack of standards for product certification. As a result, the efficiency and production capacity of bamboo products are limited.

3.1 Bamboo value chain case study: production and processing of bamboo products in Prachin Buri province

The study on bamboo value chain focused on bamboo products at Prachin Buri Province which has the highest area of bamboo plantation in Thailand. The species that are popularly grown include Pai Tong *(Dendrocalamus asper)*, Pai Sang Mon *(Dendrocalamus* spp.*)*, Pai Leang *(Bambusa* sp.*)*, etc. On this matter There are bamboo-related activities that can create value and share in the actual bamboo value chain in Thailand both unprocessed raw materials and processed bamboo products. These include bamboo seedlings, bamboo shoots, bamboo poles, bamboo plywood and quality bamboo charcoal. These products are relevant to the implementation of many sectors including the shop that sells bamboo seedling, bamboo plantations, middle man, bamboo product processing factories and consumers. Each of the sectors has different roles and responsibilities in the management of bamboo.

From the study on the processing of different types of bamboo products, it was found that each product has the investment cost including bamboo plantation management, bamboo culm grading, and processing into product before sending the product to the consumer. The value chain pattern of bamboo can be analyzed using the Michael E. Porter (1985) analytical model, which consists of two activities, the main activity and the supporting activity. Value addition to a product can be carried out using operational analysis of the main activity and supporting activity starting from the import of production factors (inbound logistics), operation process, selling the products (outbound logistics), marketing and sales, and after sales services.

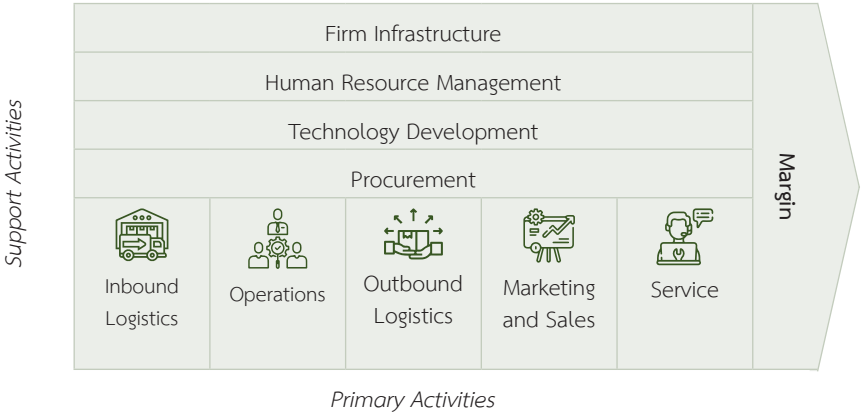

Figure 4 The analysis of the bamboo value chain

Bamboo Value Chain Analysis aims to deliver value to consumers at a level that exceeds investment cost. The main activities of the value chain are (1) Import of production factors (Inbound Logistics) which consists of the study of purchase and use of inputs. (2) Operations which is the process of converting inputs into finished products and services, starting from cultivation, land preparation, maintenance, and harvesting, (3) Outbound Logistics which is a study of the transportation of goods to warehouses or factories. (4) Marketing and Sales which is the clear classification of the consumer group and come to an understanding of the needs of the consumer group as well as creating higher sales value for the products, and (5) After sales services which is the care and service after the sale of goods or services to consumers. These main activities will be supported by support activities.

The value chain is a mechanism used to create added value to goods or services by looking at and analyzing the relevant processes and implementation starting from the inbound logistics all the way to the last consumer who utilizes the product by focusing on analyzing each process to find the ways to create value for the product to make consumers satisfied and agree to buy because they feel that the product is worth the value and beneficial as well as their personal satisfaction of the product (Office of the Civil Service Commission, 2014). The value chain analysis of the bamboo

in Thailand consists of activities as shown in Figure 5.

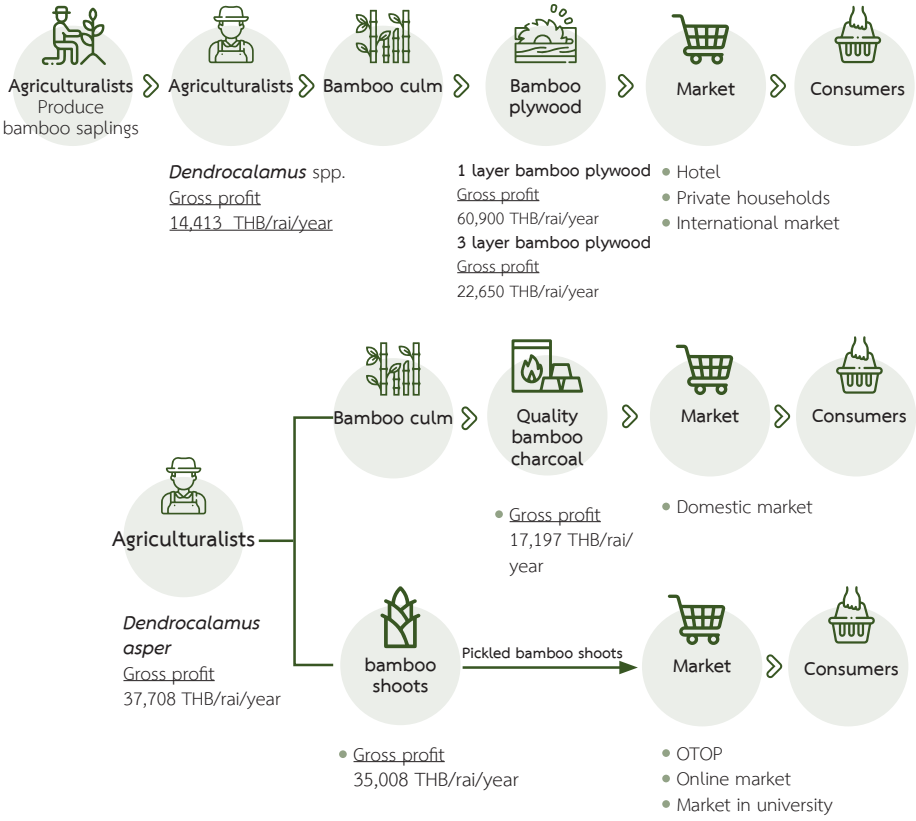

Figure 5 bamboo value chain in Thailand

3.2 Analysis of the bamboo value chain

The study on the analysis of the bamboo value chain in Thailand found that Prachin Buri is the number one province that grows the most commercial bamboos in Thailand. The bamboo value chain in Prachin Buri can be classified into 4 groups as (1) bamboo seedling stores, (2) Farmers grow bamboo to sell bamboo shoots, (3) Farmers grow bamboo to sell bamboo pole, and (4) bamboo processing factories. The analysis of the bamboo value chain in Prachin Buri was studied at every process from the inbound logistics of the production factors, operation, outbound logistics, marketing and sales, and after sales service. Including analysis of strengths, weaknesses, opportunities and threats of each value chain of bamboo products as shown in the detailed belows:

3.2.1 Bamboo seedling / sapling

In the bamboo value chain, bamboo garden/shop is the starting point of the chain. It plays an important role in the production and supply of bamboo seedlings/sapling for farmers. This case study was performed using the "Suan Pai Pun Niyom" as the case example. This bamboo plantation is located in Kabinburi district, Prachin Buri province. The plantation sells Pai Sangmon (*Dendrocalamus* spp.) and Pai Leang (*Bambusa* sp.) They manage the plantation to be used mainly for seedlings/sapling production. The overall management of the plantation includes adding chicken manure fertilizer, watering and nurturing the seedlings/sapling (Suan Pai Pun Niyom, 2020). The bamboo seedling/sapling value chain analysis is summarized as shown in Figure 6 and the gross profits from the operation are shown in Table 5 and Table 6.

Investment and expenses over 20 years**

- *Dendrocalamus* spp. 4,445,810 THB/rai
- *Bambusa* sp. 957,360 THB/rai

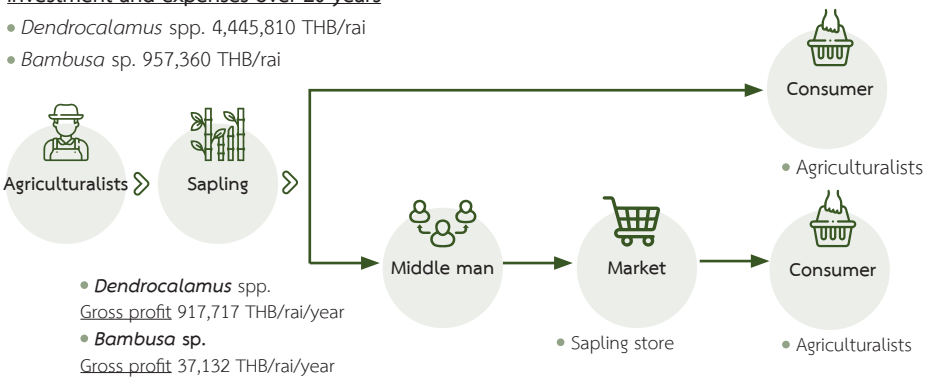

Figure 6 The bamboo seedling/ sapling value chain analysis

Table 5 Cost-benefit of Pai Sangmon (*Dendrocalamus* spp.) seedling production in 1 rai over 20 years

Activities	THB
1) Plantation cost (1st year)	**27,968**
• Pai Sangmon seedlings (400 seedling x 40 THB)	16,000
• Fertilizer (chicken manure 4,000 THB + chemical fertilizer 418 THB)	4,418
• Watering system costs	3,000
• Labor cost - two plowings (350 THB each time) = 700 THB - digging and planting (2 days x 2 persons x 350 THB) = 1,400 THB - applying fertilizer (2 days x 2 persons x 350 THB) = 1,400 THB - three rounds of weeding (3 days x 1 person x 350 THB) = 1,050 THB	4,550
2) Operating costs in the bamboo plantation 2nd year – 20th year (19 years)	**4,417,842**
• Fertilizer cost per year (chicken manure 12,000 THB + chemical fertilizer 418 THB)	12,418
• Watering system cost per year	3,000
• Labor cost per year - grafting (30,000 branches x 2 THB) = 60,000 THB - clipping branches for grafting 400 branches per day (75 days x 1 person x 350 THB) =26,250 THB - weeding (1 days x 1 person x 350 THB) = 350 THB	86,600
• Nurturing the bamboo seedling into nursery bag per year (30,000 saplings x 4.35 THB)	130,500
Total operating cost/year	232,518

Activities	THB
Total cost	4,445,810
3) Income at 2nd year - 20th year (19 years)	22,800,000
• Sales of Pai Sangmon seedling per year (30,000 seedlings x 40 THB)	1,200,000
4) Net profit over the 20-year harvest period	18,354,190
Average net profit per year	917,710

Source: field survey 2020

Table 6 Cost-benefit of Pai Leang (*Bambusa* sp.) sapling production in 1 rai over 20 years

Activity	THB
1) Plantation cost (1st year)	**21,968**
• Pai Leang sapling (400 sapling x 25 THB)	10,000
• Fertilizer (chicken manure 4,000 THB + chemical fertilizer 418 THB)	4,418
• Watering system	3,000
• Labor cost - two plowing (350 THB each time) = 700 THB - digging and planting (2 days x 2 persons x 350 THB) = 1,400 THB - applying fertilizer (2 days x 2 persons x 350 THB) = 1,400 THB - three rounds of weeding (3 days x 1 person x 350 THB) = 1,050 THB	4,550
2) Operating costs in the bamboo plantation 2nd year – 20th year (19 years)	**299,592**
• Fertilizer cost per year (chicken manure 12,000 THB + chemical fertilizer 418 THB)	12,418
• Watering system cost per year	3,000
• weeding cost per year (1 days x 1 person x 350 THB)	350
Total operating cost/year	15,768
3) Sapling production cost in the bamboo plantation 4th year – 20th year (18 years)	**635,800**
• Labor cost for digging the stump per year (4,000 stump x 5 THB)	20,000

Activity	THB
• Nurturing the bamboo sapling into nursery bag per year (4,000 saplings x 4.35 THB)	17,400
Total sapling production cost/year	37,400
Total cost	**957,360**
4) Income at 4th year –20th year (17 years)	**1,700,000**
• Sales of Pai Leang sapling per year (4,000 saplings x 25 THB)	100,000
5) Net profit over the 20-year harvest period	**742,640**
Average net profit per year	**37,132**

Source: field survey 2020

Analysis of the bamboo seedling/sapling value chain consists of the following main activities and supporting activities

1) **Inbound logistics of production factors:** The production of Pai Sangmon and Pai Leang requires spacing of 2 x 2 meters per clump, 400 clumps of bamboo can be grown in 1 rai (0.0016 km^2). In the 1st year, the soil needs to be plowed twice. Pai Sangmon seedling is sold at 40 THB/seedling which is equivalent to 16,000 THB/rai and Pai Leang is sold at 25 THB/sapling which is equivalent to 10,000 THB per rai. The labor cost for digging hole and planting is 1,400 THB, 5 kg of chicken manure fertilizer is required per clump and cost 2 THB/kg, approximately 2,000 kg is required per year which equal to 4,000 THB/rai. The chicken manure fertilizer is used together with the chemical fertilizer (N-P-K, 46-0-0) at about 38 kg/rai or 100 g/clump. The cost of chemical fertilizer is 11 THB/kg, equal to 418 THB/rai. The labor cost for fertilizer applying for 2 workers for 2 days is 350 THB/day/person which equals 1,400 THB. The Watering system costs is 3,000 THB/rai and 3 rounds of weeding costs 1,200 THB/rai.

From the 2nd year onwards, 15 kg of chicken manure is required per clump which is approximately 6,000 kg/year, at 2 THB/kg. Therefore, the cost of chicken manure is 12,000 THB/rai. It is used together with chemical fertilizer (N-P-K, 46-0-0) at about 38 kg/rai or 100 g/clump at the cost of 11 THB/kg or 418 THB/rai. One time of weeding costs 300 THB/rai and the watering system costs 3,000 THB/rai.

2) **Operation:** From the 2nd year onwards 1 clump of Pai Sangmon. About 5 culms per clump will be propagated by branch cutting, 15 branches per culm, approximately 75 branch cuttings per clump which is equivalent to 30,000 branch cuttings per rai. The number of branch cuttings can be as high as 200-300 branches per clump. As for Pai Leang, which has less branches, after the 4th year as many as 10 saplings can be dug and separated from each clump. This is approximately 4,000 saplings per rai. The production of the bamboo plantations depends on the maintenance by the farmers which include fertilizing, watering and clump management.

   Workers used in the plantations are daily hires. For the general work such as making the knob to prepare for branch cutting propagation of Pai Sangmon, the rate is 2 THB/knob. For collecting the branche cuttings from the bamboo culm and put into the soil in plastic container, the hire rate is 350 THB/day for about 400-500 branches. For Pai Leang, the rate for digging the sapling to separate from the clump is 5 THB/sapling and the worker can dig as much as 100 saplings per day. If the worker is skilled then the rate is 7 THB/sapling where they can be able to get 300 saplings per day. In addition, the nursery process for bamboo seedlings/sapling that will be moved into a plastic container will incur an additional cost per 1 container that include 0.35 baht for black husks, 1 baht per plastic container, and average 3 baht for water used to water the bamboo seedlings.

3) **Outbound logistics:** Pai Sangmon can be propagated by branch cutting from the 2nd year onwards while Pai Leang saplings can be harvested from the 4th year onwards. Bamboo seedlings/saplings must be maintained in nursery until the

seedlings/saplings have strong roots and ready to be sale to the consumers. The consumers can buy the bamboo seedling/saplings directly from the garden/ shop or order for the delivery, which will be charged according to the distance.

4) **Marketing and sales:** The price for Pai Sangmon seedlings at the plantation is 40 THB/seedling for wholesale and 40-120 THB/seedling for retail. Whereas the sapling for Pai Leang is 12 THB/sapling for wholesale and 25 THB/sapling for retail. Bamboo seedlings from seed are not popular in this business. The propagation of bamboo is mostly done by the selection of mother plant in the area to be used for propagation.

5) **After sales services:** Providing advice on bamboo plantation management to the consumers. From the study of the value chain of the shop that sell seedling/saplings of Pai Sangmon and Pai Leang in an area of 1 rai or 0.0016 km^2 based on the 20-year harvest period, it was found that Pai sangmon has a total investment cost of 4,445,810 THB and Pai Leang has a total investment cost of 957,360 THB. Selling the seedling/saplings to a middle man or directly to the consumer will generate an income of 22,800,000 THB from Pai Sangmon and 1,700,000 THB from Pai Leang. This means that the total gross profit after subtracting the investment cost for Pai Sangmon is 18,354,342 THB and for Pai Leang is 742,640 THB.

3.2.2 Bamboo plantations for bamboo shoots production.

Prachin Buri is a well-known area for growing bamboo for bamboo shoot production. Information from 2020 (as of November) indicated that the farmers growing bamboo in the Thung Bodhi sub-district of Nadi district, Prachin Buri province have formed a community enterprise and merged into a large bamboo plantation plot to grow Pai Tong (*Dendrocalamus asper*) for production of bamboo shoots and selling of bamboo pole from thinning. In the 3rd year after planted, the farmers can harvest bamboo shoots during March – December. Farmers will manage and take care of the bamboo plantation by thinning, clearing and managing the bamboo plantation to be completed by November - December. The soil was nourished by using chicken manure in January. In March, the growth of bamboo is stimulated by using fertilizer formula 46-0-0 and formula 16-16-16 in May and June to stimulate the growth of strength of the culm and help make bamboo resist to pest and disease. During the dry season, the bamboo is watered every 3 days according to the bamboo plantation management plan in Table 7. The bamboo shoot value chain analysis can be summarized as shown in Figure 7 and net profit from operations is shown in Table 8.

Table 7 The care-taking and management plan of the Pai Tong (*Dendrocalamus* spp.) from 3rd year onward

Activity	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Tending												✓
Weeding control							✓					
Watering system	✓	✓	✓	✓	✓							
Chicken manure fertilizer	✓											
Chemical fertilizer (46-0-0)					✓							
Chemical fertilizer (16-16-16)		✓	✓	✓	✓	✓	✓	✓	✓			
Bamboo shoot collector		✓	✓	✓	✓	✓	✓	✓	✓	✓		

Source: field survey 2020

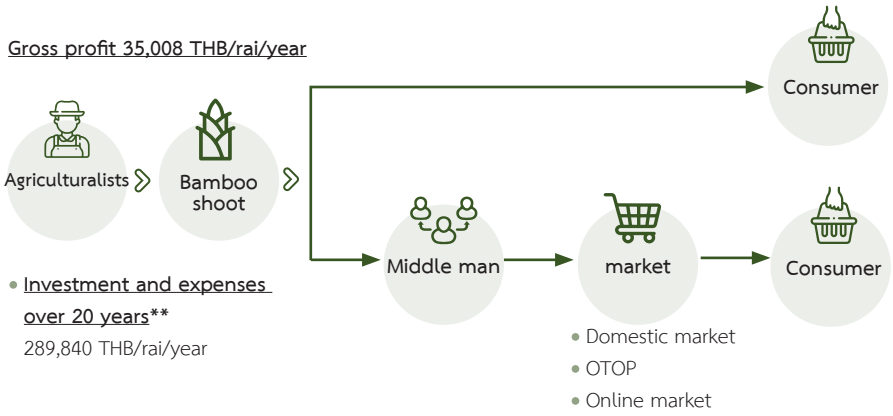

Figure 7 The bamboo shoot value chain analysis

Table 8 Cost-benefit of bamboo shoots production from Pai Tong in 1 rai over 20 years

Activities	THB
1) Plantation cost (1st year)	**12,450**
• Pai Tong seedling (100 seedings x 10 THB)	1,000
• Chicken manure fertilizer (20 kg x 100 clumps x 2 THB)	4,000
• Watering system	5,000
• Labor cost - two plowing (350 THB each time) = 700 THB - digging and planting (1 day x 1 person x 350 THB) = 350 THB - putting fertilizer (1 day x 1 person x 350 THB) = 350 THB - three rounds of weeding (3 days x 1 person x 350 THB) = 1,050 THB	2,450
2) Operating costs in the bamboo plantation 2nd year – 20th year (19 years)	**198,550**
• Chicken manure fertilizer costs per year (20 kg x 100 clumps x 2 THB)	4,000
• Watering system costs per year	5,000
• Labor cost per year - putting fertilizer (1 day x 1 person x 350 THB) = 350 THB - weeding (1 day x 1 person x 350 THB) = 350 THB - clearing and managing the clumps = 750 THB	1,450
Total operating cost/year	10,450

Activities	THB
3) Chemical fertilizer cost in the bamboo plantation 3nd year – 20th year (18 years)	**78,840**
• 46-0-0 chemical fertilizer per year (100 clums x 0.3 kg x 11 THB)	330
• 16-16-16 chemical fertilizer per year (100 clums x 2.7 kg x 15 THB)	4,050
Total chemical fertilizer cost/year	4,380
Total cost	289,840
4) Income at 3rd year –20th year (18 years)	**1,044,000**
• Sales of bamboo shoots in off-season per year (1,000 kg x 30 THB)	30,000
• Sales of bamboo shoots in season per year (5,000 kg x 5 THB)	25,000
• Sales of bamboo pole per year (3 culms x 100 clumps x 10 THB)	3,000
Total income/year	58,000
5) Net profit over the 20-year harvest period	**754,160**
Average net profit per year	37,708

Source: field survey 2020

Analysis of the bamboo shoot value chain consists of the following main activities and supporting activities

1) **Inbound logistics:** The cultivation of Pai Tong for harvesting the bamboo shoots in the 1st year requires plowing of the land 2 times which costs 700 THB/rai. The seedlings are to be grown using a spacing of 4 x 4 m, thus in 1 rai there will be 100 clumps. The seedling cost is 10 THB/seedling accounting to 1,000 THB and labor cost for planting is 350 THB/day for 1 day. The 3 times weeding cost is 1,050 THB and the water system costs 5,000 THB/rai. Approximately 20 kg of chicken manure is required per clump, at 2 THB/kg, the cost of chicken manure is 4,000 THB/year. In addition, there is the cost of labor for fertilizer applying at 350 THB.

2) **Operation:** The production of bamboo shoots needs irrigation system by watering every 3 days with a sprinkler system during the off-rainy season or during January to May. In January 20 kg/clump of chicken manure is to be applied. The cost is 2 THB per kg which equivalent to 4,000 THB/year. There is a labor cost for fertilizing of 350 baht and 1 time weeding of 350 baht. In the 2nd year, the old and adjacent bamboo needs to be thinned out. This is done during November to December to allow the newly grown bamboo to grow to its full potential by having left 3-4 bamboos per clump to raise clumps and rearing new shoots. The labor cost for thinning and grazing the clumps is 750 THB/rai/year. From the 3rd year onwards approximately 0.3 kg/ clump of chemical fertilizers (N-P-K, 46-0-0) is used. The cost of the fertilizer is 11 THB/kg which is 330 THB/rai. The 0.3 kg/clump of (N-P-K, 16-16-16), 15 THB/kg is also applied for 9 times from February to October.

3) **Outbound logistics:** Bamboo shoots from Pai Tong that are 3 years old and over can be harvested and sold. Farmers can sell the bamboo shoots for 30 THB/kg and they can collect for 3 days per time, each time yielding approximately 25 kg of bamboo shoots and will produce about 250 kg per month. In addition,

there are off-season productions during February to May and in these 4 months the off-season shoot production is approximately 1,000 kg/rai accounting for an income amount of 30,000 THB/rai. In the rainy season or during June to October the production of bamboo shoots is more than the market demands where there may be a much as 1,000 kg/rai/month therefore the price of bamboo shoots in this season may decrease to 5 THB/kg equal to 5,000 THB/ rai/month. After the rainy season start from December bamboo will dormant and it is the time to clean the clump. This makes bamboo shoots become less productive for a certain period. The price of bamboo shoots during this period was higher because the market demand was higher than the available production. In addition, farmers will have income from selling bamboo culm from thinning, which can be sold at a price of 10 baht or more per culm. Which will have income from selling bamboo culm about 3,000 THB/ rai

4) **Marketing and sales:** The market for fresh bamboo shoots both in and off season is mostly domestic market. There are local markets for selling them. As for the bamboo shoots in the rainy season that come out in excess of the market, the price will be low and the farmers will process them into pickled bamboo shoots. which can increase the value up to 70 baht per kilogram. The market for processed pickled bamboo shoots has a wider market than the fresh bamboo shoots such as the Community Product Market in universities, and One Tambon One Product (OTOP), etc. Moreover, there are promotions about the products through online media and some farmers have also been involved with universities to conduct research studies and develop products continuously.

5) **After sales service:** Bamboo shoot production has no after-sales service to consumers but it will always produce quality and standard products. From the study of the bamboo shoots value chain of Pai Tong in an area of 1 rai over the period of 20 years it was found that the total expense for inbound logistics and operation cost was 289,840 THB and the sales to the middle

man or direct sales to consumers generates an income of 1,044,000 THB. Therefore, the production of bamboo shoots from Pai Tong will have a profit after deductions of investment costs equal to 754,160 THB.

3.2.3 Bamboo plantations for culm production

The culm is the part of the bamboo that can be used more than any other parts. Culms can be cut for use after the bamboo is matured at 3 years old or more. Uses of bamboo culm can be classified into use for construction, processing into packaging or a wicker handicraft product or wholesale to factory to be processed into various products such as furniture, bamboo plywood, chopsticks, and quality bamboo charcoal, etc. The analysis of the bamboo culm value chain can be summarized as shown in Figure 8 and the net profit from the operation is shown in Table 9.

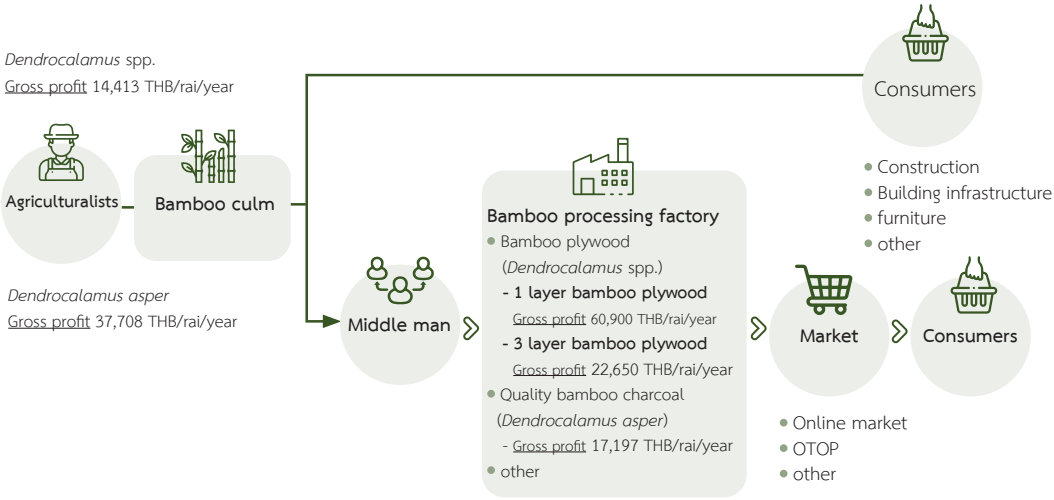

Figure 8 The bamboo clum value chain analysis

The production of Pai Sangmon (*Dendrocalamus* spp.) has investment cost for the production which are the initial coast for investment including the cost of sapling, chicken manure, and labor cost for fertilizing and taking care of the plantation. However, the value of bamboo culms will increase if they are used to produce other scaled up products according to the required use. Selling the culms of Pai Sangmon may require a large volume of sells at a time in order to be cost-effective enough for transportation and handling. Every step has a cost to manage. Therefore, the buyer and seller must agree on a fair price so that no one may cause damage or loss

Table 9 Cost-benfit of bamboo clum production of Pai Sangmon in 1 rai over 20 years

Activity	THB
1) Plantation cost (1st year)	**10,450**
• Pai Sangmon saplings (100 saplings x 40 THB)	4,000
• Chicken manure (100 clumps x 5 kg x 2 THB)	1,000
• Water system cost	3,000
• Labor cost - two plowing (350 THB each time) = 700 THB - digging and planting (1 day x 1 person x 350 THB) = 350 THB - chicken manure fertilizer (1 day x 1 person x 350 THB) = 350 THB - weeding (3 days x 1 person x 350 THB) = 1,050 THB	2,450
2) Operating cost in the bamboo plantation 2nd year – 20th year (19 years)	**70,300**
• Chicken manure fertilizer cost per year (100 clumps x 15 kg x 2 THB)	3,000

Activity	THB
• Labor cost per year	700
- applying fertilizer (1 day x 1 person x 350 THB) = 350 THB	
- weeding (1 day x 1 person x 350 THB) = 350 THB	
Total operating cost/year	3,700
3) Labor cost for cutting the culms in the bamboo plantation 3rd year – 20th year (18 years)	**81,000**
- Labor cost per year (4,500 THB x 1 times) x 18 years = 81,000 THB	
Total cost	161,750
4) Income at 3rd year –20th year (18 years)	**450,000**
• sales of bamboo culms per year (5 culms x 100 clumps x 50 THB)	25,000
5) Net profit over the 20-year harvest period	**288,250**
Average net profit per year	14,413

Source: field survey 2020

Analysis of the bamboo culm value chain consists of the following main activities and supporting activities.

1) **Inbound logistics:** The important activities consist of in the 1st year where the bamboo producer or the farmers start to plant Pai Sangmon (during May – July). The activity begins with 2 plowing and landscaping adjusting amount to 700 THB/rai. The farmers then plant the sapling with the 4 x 4 m. spacing. So there are 100 saplings/rai. The farmers will buy the saplings from nearby plantations or may producing their own saplings which will help reduce the cost of saplings. There is labor cost for planting the sapling at

350 THB/day. Chicken manure is applied at the bottom of the hole so that the bamboo can extract nutrients for better growth. In the first year, use 5 kg per clump, price 2 baht per kg, equivalent to 1,000 baht. Labor cost for fertilizing 350 baht. Irrigation system 3,000 baht per rai. Labor cost for weeding 3 times is 1,050 baht.

2) Operation: From the 2nd year onwards, applying chicken manure 15 kg per clump, price 2 baht per kg, equivalent to 3,000 baht, labor cost for 1 time fertilizing is 350 baht and 1 time weeding is 350 baht. From the 3rd year onwards, there is the cost for culms harvesting which is a lump sum of 4,500 THB/rai. When the bamboo reaches 1 year of age the farmers can harvest bamboo shoots for consumption and sell some. When the bamboo is matured at 3 years old the farmers will have income from selling the bamboo culms. The care-taking and management plan of the Pai Sangmon is shown in Table 10.

Table 10 The care-taking and management plan of Pai Sangmon

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
clearing the culms											✓	✓
weeding control						✓	✓			✓	✓	
chicken manure fertilizing						✓	✓					
sell the bamboo culms	✓	✓	✓	✓								✓

Source: field survey 2020

3) **Outbound Logistics:** Bamboo culm at 3-years old is appropriate for harvesting and utilizing. The culm will be selected and cut by the farmers. After the selection is made then it will be cut down using human labor or electric chainsaw and preparations are made to send them to the factories or sell them directly to a buyer or a middle man at the cost price of 50 THB/culm for the length of 15 m and a diameter of 3 inches or more according to Table 11. The lump sum cost for culms harvesting is 4,500 THB/rai.

Table 11 The selling price of bamboo is based on the diameter and length of the culm

Diameter of bamboo culm	Length of bamboo culm	Price (THB)
0.5 inches	Length 15 m.	15
2 inches	Length 15 m.	25
3 inches	Length 15 m.	50

Source: field survey 2020

4) **Marketing and sales:** Most of the market is domestic markets such as various processing factories, furniture market, and building and construction, etc. The culm of Pai Sangmon can be sold at 15-50 THB/culm. The price depends on the volume of the order, length, thickness, diameter, part of the culm (bottom, middle, top), specific characteristic of the culm is that it must be straight, not bent. The price will be negotiated between the farmer and the middle man or the consumer directly. However, the price of culm in the domestic market is still different for each locality and the majority of farmers promote their products through online media such as Facebook, websites, and webpages which makes it much easier to communicate if there are any issues or questions.

5) **After sales services:** There is no after sales service for the culms that are sold and moved out of the plantation. There will be coordination communications only for buying and selling of the culm, and bargain the price for next purchase only. From a study of the value chain of Pai Sangmon in an area of 1 rai over a period of 20 years, it was found that the culm production of Pai Sangmon have inbound logistics and operation expenses totaling 161,750 THB and the selling of the culm to a middleman or direct customer with income of 450,000 THB. Therefore, the culms production of Pai Sangmon will have a net profit after deducting the investment cost of 288,250 baht.

3.2.4 Bamboo plywood factory

Recently, bamboo plywood is a popular product as part of construction materials such as for flooring, inner walls of buildings and for making various types of furniture because they are beautiful, durable, no stretch and is a good insulator. Moreover, bamboo plywood can bare more load than normal wood and looks like real wood. The production process of bamboo plywood has a value chain starting from the farmers selling the bamboo culm to the middleman. The middleman then sells it to the processing factory, and lastly the factory processes the culm into products and sells it to the consumers. The production of bamboo plywood has details of production costs according to types and sizes of products such as 1 layer bamboo plywood with the dimension of 200 x 2,400 x 6 mm, and 3-layer bamboo plywood with the dimension of 1,200 x 2,400 x 15 mm. In addition,

there is a cost of about 10 machines, with the first factory set up will require an investment of more than 80 million THB. (Thana Thipcharoen, 2020a). Hence, the analysis of the bamboo plywood value chain can be summarized as presented in Figure 9 and the net profit from the operations in Table 12.

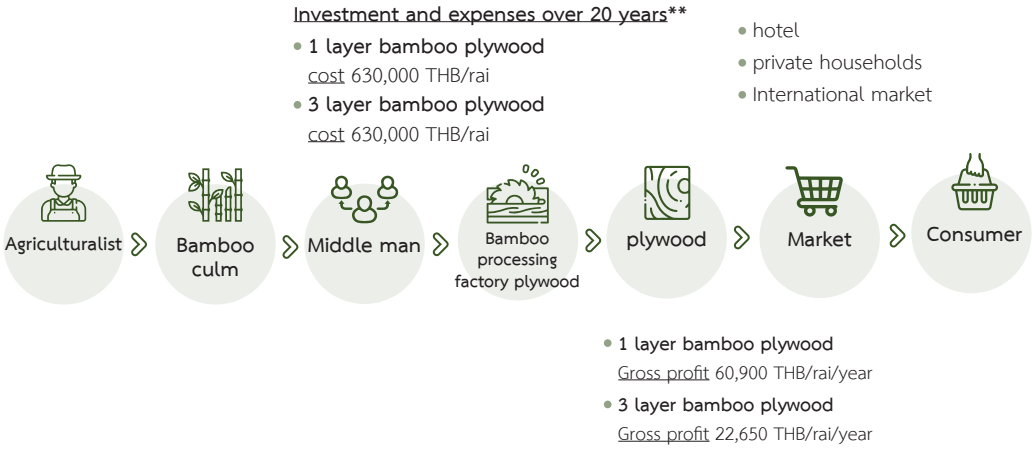

Figure 9 The bamboo plywood value chain

Table 12 Cost-benefit of bamboo plywood production in 1 rai over 20 years

Activity	THB
One layer bamboo plywood production	
1) Cost of one layer bamboo plywood production in 1st year – 20th year (20 years)	**630,000**
• Cost of bamboo culms for bamboo strip production per year (500 culms x 60 THB)	30,000
• Production cost (2% of Bamboo strip production)	600
• Management costs (1.5% of Bamboo strip production)	450
• Marketing costs (1.5% of Bamboo strip production)	450
Total cost per year	31,5000
2) Income in 1st year – 20th year (20 years)	**1,848,000**
• sales of one layer bamboo plywood (6 mm) per year (56 sheet x 1,650 THB)	92,400
3) Net profit of one layer bamboo plywood production over the 20-year harvest period	**1,218,000**
Average net profit per year	60,900
Three layers bamboo plywood production	
4) Cost of three layer bamboo plywood production in 1st year – 20th year (20 years)	**630,000**
• Cost of bamboo culms for bamboo strip production per year (500 culms x 60 THB)	30,000
• Production cost (2% of Bamboo strip production)	600
• Management costs (1.5% of Bamboo strip production)	450

Activity	THB
• Marketing costs (1.5% of Bamboo strip production)	450
Total cost per year	31,5000
5) Income in 1st year – 20th year (20 years)	**1,083,000**
• sales of three-layer bamboo plywood (15 mm) per year (19 sheet x 2,850 THB)	54,150
6) Net profit of three-layer bamboo plywood production over the 20-year harvest period	**453,000**
Average net profit per year	22,650

Source: field survey 2020

Analysis of the bamboo plywood value chain case study of Pimtha Co. Ltd. in Prachin Buri province consists of main activities and supporting activities as follows.

1) **Inbound logistics:** Inbound logistics begins with buying Pai Sangmon directly from the farmers or from the middleman at Lampang province. The factory buys at approximately 60 THB/culm. However, bamboo costs may increase due to the logistic cost from bamboo culm production sites. This will increase the cost of production until it may cause a loss. The factory also had to prepare some stocks of the bamboo raw materials so that the production line could continue without interruption. This is because bamboo raw materials are sometimes scarcely obtained especially during the rainy season due to limitations in harvesting and transportation. The bamboo culm that can be used to make plywood must be at least 3-year-old with a diameter of 3-4 inches and a thickness of at least 1.5 cm. The culm used must be straight. The unused parts of bamboo will be an additional cost. Therefore, the factory has to figure out how to process the extracted parts of bamboo into other products that can add value such as coarsely chopped bamboo walls, smooth surface bamboo plywood walls, and treated bamboo culms, etc. (Thana Thipcharoen, 2020b).

2) **Operation:** The operation process in the production and processing consists of 2 steps which are (1) preserving the bamboo timber using chemical to protect them from insects and fungi, (2) the production of bamboo plywood begins with cutting the bamboo culm to a length of 2.50 m. and slicing into 7 pieces, each piece is approximately 2 cm. wide, 1.5 cm. thick, then thinned by using a splitter to have a thickness of about 6 mm. After that, each bamboo sheet is arranged and glued to be 120 cm. wide and 240 cm. long to assemble into plywood. One-layer bamboo plywood will use 62 bamboo strands per sheet, and three-layer bamboo plywood will use 186 bamboo strands per sheet, and then move to high-pressure heat presses. Finally, the plywood sheets are sanded to be smooth and prepared for further sale.

3) **Outbound logistics:** The amount of bamboo plywood produced is approximately 35% of all the raw materials brought in. The remailing 65% of all the materials will be used to process into other products to add value and decrease the investment cost as much as possible. For example, the remaining raw materials can be used to make coarsely chopped bamboo wall, smooth surfaced bamboo plywood, treated bamboo culm, bamboo flooring, and bamboo straws, etc. There is also sawdust or unused materials from this production which can be sold or given to the farmers or interested people to use as a soil quality improvement in the bamboo plantation or used for other purposes. The transportation of bamboo plywood to the consumers will be a 10-wheel truck to transport goods to construction retail stores both for small retails and large wholesalers and to the locations as identified by customer. This process has operational cost which is labor costs, vehicle costs, fuel costs for transportation of goods.

4) **Marketing and sales:** Bamboo plywood can be sold to specific consumer groups. A large portion of the market is the hotels in Thailand, private households and the international market in the USA. Plywood prices can be divided into 6 mm. plywood sheets, priced at 1,650 baht per sheet, and 15 mm. plywood sheets, priced at 2,850 baht per sheet. Apart from the bamboo plywood

and other bamboo products the company also offers services for the design for bamboo buildings, construction of bamboo buildings and provide consultancy for work dealing with bamboo for the customers with a team that has over 20 years of experience. In this process sales promotion can also be initiated using salesperson that has knowledge of the product or goods. This opportunity should also be taken to create a good relationship between consumers and the salesperson. Sales advertisement channels should also be increased to make the product well known in the market. Other than that, sales proposal can be made through online channels so the consumers can self-order the products and have a look at the products before they make the decision to buy.

5) **After sales service:** In selling bamboo plywood for use in construction, building infrastructure or making furniture for interior design, after sales service is provided to follow up on the results after sales have been made. After sales service include installation and setting up of the product, maintenance, and have return and exchange service after the goods or products have been handed over to the consumer. The products from bamboo plywood can last for more than 10 years.

From the study of the value chain of bamboo plywood, the main production costs are machines and factories that are worth more than 80 million THB. However, this amount cannot be used in the assessment of the initial investment because the amount of products produced in each year is very different depending on the purchase orders form the consumers which is not consistent. However, on this matter, the initial investment cost of operation during year 1 to year 20 for the bamboo culm in 1 rai composed of the cost of the bamboo culm, the production process, management, marketing, production of 1 - layer bamboo plywood of 630,000 THB, and production of 3 - layers bamboo plywood of 630,000 THB. The income from the 1 - layer bamboo plywood is 1,848,000 THB and from the 3 - layers bamboo plywood is 1,083,000 THB.

The total net profit throughout 20 years period for the 1 - layer bamboo plywood is 1,218,000 THB and for the 3 - layers bamboo plywood is 453,000 THB.

The study on the bamboo plywood value chain found that the relevant operators consist of the farmers who grow bamboo, middle man who sells bamboo to processing factories and process it into bamboo plywood and then sells to the consumers. The majority of the market is the 5-star hotels in the country or some may be the consumers who use them directly in the construction work and the international market. Other than this, the tendency for the requirements to use bamboo plywood in Thailand and other countries is continuously increase, especially in the furniture industry group who imports bamboo from abroad. This is because the supply of wood used in the production process for the furniture industry is not sufficient. Therefore, the production of bamboo plywood is on the way to produce alternative plywood. This is because bamboo has a rapid growth rate and consists of properties that can be used to substitute real wood. Therefore, if there is enough bamboo supply to feed the plywood production process and to produce other bamboo products, it would create more opportunity for Thailand to help increase the income for the country through the processing of plywood.

3.2.5 Quality bamboo charcoal factory

Quality bamboo charcoal is made from bamboo trunks that have been burned at high temperatures above 1,000 °C. Bamboo quality charcoal products can be used to make energy alternatives to oil or coal. This energy source emits less pollution than fossil fuel. Furthermore, quality bamboo charcoal has been applied in many aspects of daily life. It can be used as part of medicine as well. At present, Thailand is exporting products form quality bamboo charcoal to the global market in moderate amounts and that supply is not sufficient for either

the domestic or global market. With the unique properties of bamboo that are very porous results in more than 85 percent of highly stable carbon and hundreds of minerals.

The kiln used in producing quality bamboo charcoal was invented from local wisdom together with the knowledge from a Japanese expert. It was built in 1997 with the investment cost about 1 million THB. Recently, it has been used for over 20 years. The maintenance is 2 times a year with the cost of maintenance being 10,000-20,000 THB. There is also a big maintenance that is scheduled once every 3 years which costs around 30,000-50,000 THB (Kitti Lert-lum, 2020). The analysis of the quality bamboo charcoal value chain is summarized as shown in Figure 10 and the net profit from operation as shown in Table 13.

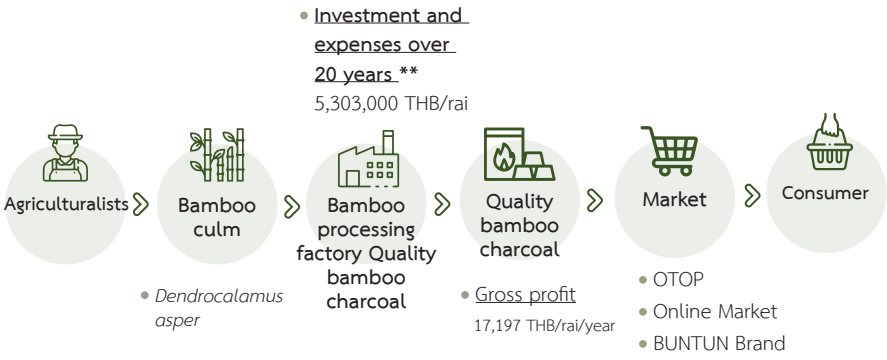

Figure 10 The bamboo charcoal value chain

Table 13 Cost-benefit of the quality bamboo charcoal in 1 rai over 20 years

Activities	THB
1) Cost of building and maintaining the kiln	**2,110,000**
• Cost of building the kiln (the kiln used for over 20 years.)	1,000,000
• Annual maintenance (19 years x 40,000 THB)	760,000
• Big maintenance every 3 years (7 times x 50,000 THB)	350,000
2) Operating costs in 1st year – 20th year (20 years)	**3,193,000**
• Cost of bamboo culm per year (15 times x 1.5 tons x 1,500 THB)	33,750
• Labor cost per year (22 days x 2 persons x 350 THB)	15,400
• Fuel cost per year (15 times x 2 canister of gas x 350 THB)	10,500
• Packaging cost per year	100,000
Total operating cost /year	159,650

Activities	THB
Total cost	**5,303,000**
3) Income at 1st year – 20th year (20 years)	22,500,000
• Sales of bamboo charcoal Grade A per year (15 times x 50 kg x 450 THB)	337,500
• Sales of bamboo charcoal Grade B per year (15 times x 150 kg x 350 THB)	787,500
Total income/year	1,125,000
4) Net profit over the 20-year	**17,197,000**
Average net profit per year	**859,850**

Source: field survey 2020

Analysis of the quality bamboo charcoal value chain consists of the following main and supporting activities.

1) **Inbound logistics:** The steps of production of the quality bamboo charcoal begins with buying bamboo culm directly from the farmers from plantations that are clearing their bamboo clump to harvest bamboo shoots which the time when the culms are most appropriate for use in producing quality bamboo charcoal. The bamboo that is suitable for producing quality bamboo charcoal should be bamboo that is 3 years old or more. It can be used as a whole, such as Pai Tong, Pai Leang, etc. Bamboo culms used must not decay or break, which the factory will buy fresh bamboo at a price of 1,500 baht/ton or dried bamboo at a price of 1600 baht/ton. If the country's economy is good, the purchase price will be as high as 1,800 baht/ton because the factory wants to help farmers to get good income.

2) **Operation:** In the operations of production and processing, before the bamboo is put into the kiln, the bamboo must be cut to 1 meter in length. One kiln can contain approximately 1,500 kg of bamboo at a time. The temperature used

in the combustion must not be less than 1,000 °C, using fuel from 2 gas tanks as the starting fuel. The cost of gas is 350 THB per tank. Once the burning process is complete, we will get quality bamboo charcoal which can then be used for various benefits. The processing process requires skilled workers in implementing the processing work and produce quality bamboo charcoal. Moreover, the products produced have to have variety of use, be modern and sufficient enough for the market requirements. In the processing part there should be technological development in the burning process or use materials and equipment that has good quality and efficiency in production. At the same time, it is important that the selection of raw material should be sufficient and appropriate for each batch of production. This is to ensure that the products are of good quality and can be distributed for sales more to both in the domestic and international market.

3) **Outbound logistics:** Burning 1 batch of culms will produce approximately 200 kg of quality bamboo charcoal. Before it can be sold, the charcoal needs to be graded. Grade A is the best quality which is approximately 25% of the products produced and is sold at 450 THB/kg Grade B is approximately 75% of the products produced and this is sold at 350 THB/kg After the products are graded and separated, they are packed in the container for transport directly to the customer or to the middle man as well as secondary processing factories that will use it to make other products. Other than this, in cases where the consumers order the goods online, the store can use the post as another channel to send the goods as well.

4) **Marketing and Sales:** The market for quality bamboo charcoal is mostly domestic market and specific customer group. There are many channels of distribution of the goods including the OTOP market hosted by the Community Development Department, online market, family-owned business under the name of BUNTON, and universities that have expressed interested in helping with the marketing for the factory. This is to reach out to a wider scope of consumer and open up more channels for consumers to ask or express their

questions and it also allow them to order the goods and see them before making the decision to buy through online media. Quality bamboo charcoal is a highly specific health product that uses high levels of technique and wisdom in the production process. Therefore, there are no other goods that can replace it. There are many entrepreneurs who try to make quality bamboo charcoal to feed into the market but they lack the knowledge in the burning process for quality charcoal. This makes the charcoal that they produced have low quality and cannot be sold to foreign markets while the domestic consumers that buy the products that are made of lower than standard qualities, resulting in reduced benefits.

5) **After sales service:** Services are given for how to use the product and delivery to consumers. However, production of quality bamboo charcoal is still very limited at present. There are some entrepreneurs producing quality bamboo charcoal for export to sell abroad. It is a good opportunity if Thailand turns to produce or process bamboo to have quality that can be sold abroad. This will add value to bamboo.

From the study of the quality bamboo charcoal value chain, it was found that the important investment in the production is the cost of the kiln which is about 1 million THB/kiln. It can operate for as many as 20 years with regular annual maintenance and continuous big maintenance. There are also initial expenses per production in years 1-20 which include the costs for bamboo culm, labor, fuel, and container. The cost of construction of a kiln and a total operating cost of 5,303,000 baht. The total income is 1,125,000 THB/year. Net profit over the life of the kiln (20 years) totals 17,197,000 baht, which represents an average net profit of 859,850 baht per year.

From the comparison of the weight of Pai Tong per rai, it was found that Pai Tong weighs approximately 30 kilograms per culm. The farmers will cut about 3 culmss per clump per year where the clumps are grown at the 4 x 4 spacing. Therefore, there are 100 clumps per rai. Based on the weight of the culm, it can be calculated that the weight of culm per rai is approximately 9 tones. Throughout 20 years of operation, approximately 450 tons of bamboo or 50 rai of bamboo were used. If using 1 rai of Pai Tong to produce and process it into quality bamboo charcoal, it will have a 20-year total net profit of 343,940 baht. The average net profit per year is 17,197 baht.

3.3 Summary of the bamboo value chain case study: production and processing of bamboo-based goods from Prachin Buri

Bamboo is a plant that can be utilized in production of variety of products. It can help add market value through many methods such as secondary processing to add value to the goods. Also, it can respond to the utility requirements of the consumers in various ways such as in the form of bamboo plywood, floorings and high-quality bamboo charcoal, etc. This study on the value chain of bamboo in the Prachin Buri case study focused on studying the goods from bamboo that has actual linkages to the present-day economy. Therefore, the scope of study set boundaries for the goods to be studied including bamboo sapling, bamboo shoots, bamboo culm, and bamboo plywood and quality bamboo charcoal. It was found that the goods can be classified into 2 groups being (1) raw material group which consists of bamboo sapling, bamboo shoots and bamboo culm, and (2) processed goods group which include bamboo plywood and quality bamboo charcoal. The comparison of the investment, expenses, net profit of the bamboo-based products per rai over 20 year period of production and sales distribution of each of the goods is as shown in Table 14.

Table 14 The comparison of cost-benefit of the bamboo-based products per rai over a 20 years period of production and sales distribution of each of the goods

bamboo-based products		Total cost over 20 years (THB)	Net profit over 20 years (THB)	Net profit / year (THB)
Sapling	Pai Sangmon	4,445,810	18,354,190	917,710
	Pai Leang	957,360	742,640	37,132
Bamboo shoot	Pai Tong	289,840	700,160	35,008
Bamboo culm	Pai Tong		54,000	2,700
	Pai Sangmon	161,750	288,250	14,413
Bamboo plywood*	1 - layer bamboo plywood	630,000	1,218,000	60,900
	3 - layer bamboo plywood	630,000	453,000	22,650
Charchoal	Quality bamboo charcoal	106,060	343,940	17,197

Remark: *These values did not include the investment cost of machines and factory construction because the amount of product in each year is very different depending on the purchase order of the consumers which is inconsistent.

Table 14 indicate that the production of Pai Sangmon for the purpose of selling the seedlings generates the highest profit in comparison to the other group of bamboo-based goods by generating a net profit of 917,710 THB/year. Second to that is the production of 1 - layer bamboo plywood which has a net profit of 60,900 THB/year. Whereas, the production of sapling of Pai Leang and bamboo shoots of Pai Tong have the average net profit of 37,132 and 35,008 THB/year respectively. The production of 3 - layers bamboo plywood which has higher investment costs than the 1 - layer bamboo plywood has an average profit of 22,650 THB/year. The production

of quality bamboo charcoal has a net annual profit of 17,197 THB/year. Sales of Pai Sangmon culm generates gross profit of 14,413 THB/year and sales of Pai Tong culm generates gross profit of 2,700 THB/year which is the least profit generated compared to other types of goods but the sales of the Pai Tong culm are only additional income from the sales of bamboo shoots.

The business of processing bamboo products such as bamboo plywood production and the production of quality bamboo charcoal has a relatively high investment, namely the cost of machinery for the production of bamboo plywood and a kiln to produce high quality bamboo charcoal. However, the machines for such production have a long service life of more than 10 years. Therefore, it is still worth for the investment compared to the profit received along with effective marketing of the entrepreneurs.

However, the production of plywood in Thailand is still very limited. Both in terms of the amount of production each year that is very volatile due to the production volume also depends on the order quantity of a specific group of consumers. If consumer demand is high, it will be worthwhile for entrepreneurs. This causes the production of bamboo plywood to be inconsistent for each year. In addition, the production of bamboo plywood requires straight Pai Sangmon that the lower portion of the bamboo can be used in the production process. This resulted in an excess cost of production because the whole culm of bamboo had to be purchased for the production of bamboo plywood.

For the bamboo seedling/sapling production, bamboo culm production and bamboo shoot production, there are important production costs such as seedling costs, fertilizer costs, and other operating costs, especially for the production of bamboo seedlings/sapling that can be produced and sell almost all the year while Bamboo culm production can be produced and sold 3 years after the bamboo has matured in diameter which can only be cut once a year. For the cultivation of bamboo for harvesting and selling of bamboo shoots, the bamboo shoots can be harvested from the 2nd year onwards and they can be sold almost all year. During the rainy season, there is a lot of bamboo shoots and may cause the product to exceed the market demand.

If bamboo shoots are processed into pickled bamboo shoots or other processed, they will generate more income than selling only fresh bamboo shoots.

The study of the bamboo value chain in Thailand had analyzed the full chain from the inbound logistics of the production factors, the operation process, outbound logistics, marketing and sales, and after sales services. The strengths, weaknesses, opportunities and threats that occurred in the value chain can be summarized as follows.

Environment and Potential Analysis of Bamboo

Strengths	Weaknesses
- There are many species of bamboo in Thailand, so they can be utilized in many ways. - Bamboo can be used in many different ways and can be used as raw materials for energy production and have low environmental impact. - Bamboo is a fast-growing plant and have little disease and natural enemies. - Bamboo can be grown together with other types of economic plants making a worthwhile use of the land.	- Farmers still lack the knowledge in management of a bamboo plantation and lack the information and researches to scale up commercially. - The investment and development of bamboo industry still lacks continuity. - The farmers cannot generate income in the first 3 years of the production of bamboo culm. - The source of bamboo resources that can be used for economic purposes is insufficient.

Strengths	Weaknesses
- Bamboo is relevant to the daily life in much aspect such as food, furniture, and energy, etc. - The demands for products from bamboo in the global market has the tendency to continuously increase, especially as wood substitute, eco-friendly material and products. - The targets and policy to move towards sustainable development results in utilizing the resources more efficiently. - The global trend for environmental conservation created changes in the production of energy and prefers renewable sources with low environmental impact therefore bamboo is one of the appropriate choices of plant to use for producing energy.	- The policy mobilization still lacks clarity. - There is no agency with direct responsibilities and the relevant agencies lack integration and cooperation. - The central market for buying and selling bamboo is limited. Therefore, the price of bamboo culm is still dependend on the negotiation between the middle man and the farmer. - Thailand still lacks the technologies relevant to the development of bamboo.

4

Policy recommendations on management of bamboo resources

The value chain study of Thai bamboo has been studied from the inbound logistics process of the production factors, operation, outbound logistics, and marketing and after sales services which lead to the the identification of strengths, weaknesses, opportunities and threats in the operation. Furthermore, a workshop was held on 25th December 2020 to present and exchange ideas on the findings of the study and analyze the strategies on resources mobilization sustainably by consultation with stakeholders and relevant sectors from the government sector, private sector and academic sector. There were 33 participants in the workshop.

From the meeting, there were four policy proposals that can be compiled namely: creating environment and environmental policies that are conducive to production and trade, creating understanding on the management of bamboo to increase productivity, supporting marketing and trade promotions, and perform research and studies for the next phase. The recommendations can be summarized as follows.

1) **Creating environment and environmental policies that are conducive to production and trade**

   - Have a clear policy and directions for supporting and promoting the activities throughout the bamboo value chain in Thailand.
   - Review and amend the relevant laws to facilitate the use of bamboo from various forest zones to reduce the obstacles in using bamboo for value added products.
   - Promote the use of and processing of products from bamboo to be equivalent to other economic crops.
   - Set up a main unit to manage bamboo at the national level. and integrate cooperation between relevant agencies or the private sector to take part in driving bamboo to have a sustainable market mechanism, such as sugarcane factories, etc.

2) **Create understanding on the management of bamboo to increase productivity**

   - Provide knowledge dissemination on how to select the appropriate species of bamboo for the locality, how to select the bamboo that is popular or in market demand, and selection method for the parts of bamboo to be used for processed products.
   - Encourage the availability of quality, reliable seedlings at fair prices in order to increase the number of seedlings. sufficient to meet the market demand.

- Support the farmers to grow other plants or catch crops such as cassava or other crops mixed with the bamboo so that they may have income in the first 3 years because in the 1-3 year the farmers will not gain income from selling the bamboo culm.
- Set a standard for the production of seedling/sapling and ensure that the origin can be traced.

3) Supporting marketing and trade promotions

- Upgrading and prioritize bamboo to be an important economic crop of the country.
- Establish a unit to determine the central price and the central market for the sale of bamboo seedlings/sapling and bamboo culm.
- Promote Small and Medium Agricultural Enterprises (SMAEs) so that they have knowledge on marketing management and can use it to further develop and scale up their implementation efficiently.
- Support production technology and innovations to increase the value of bamboo-based products and be environmentally friendly.
- Promote the aggregation of large bamboo plantations agricultural community enterprise at the provincial level.

4) Research and studies for the next phase

- Perform researches on the conservation and utilization of bamboo resources to create continuity and ensure that the research results can be scaled up for the user at the commercial level.
- Promote and support the private sector to compete and develop production and processing technology and innovations for bamboo products.
- Develop a format for developing high value of bamboo product that is in line with both domestic and international market demands.

- Have a research, development and innovation unit for bamboo and disseminate the knowledge from the research to the farmers and small scaled entrepreneurs.
- Developing the value chain of bamboo in Thailand to connect activities into the same chain.
- Establish a bamboo genetic collection center in Thailand for the benefit of conservation and further research

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