

Zero Waste Management to Increase Efficiency in Palm Oil Production and Processing for Food Security in Thailand

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Abstract

This study aims to analyze the structure of palm oil production and government policies related to the stability of food consumption in order to meet the future demand in the next 20 years (2014 - 2034). Applying the principle of zero waste management, the study uses a market value approach by assessing the value of all remainders of oil palms. The remains of oil palms, such as debris, leaves, stem, and shell fiber, were valued. These remains were converted to fertilizers. Organic wastewater from the crude palm oil production process is used to produce electricity. The value of these remains is approximately 919.35 million USD per year consisting of: (1) the weight of all debris, palm leaves, and shell fiber in Thailand is about 3.64 million tons per year, equivalent to 243.44 million USD of fertilizers; (2) the weight of palm oil trunks is 89,958 tons per year, equivalent to 6.00 million USD of fertilizers; (3) the weight of empty fruit bunches, palm fiber, and waste water is 2.86 million tons per year; equivalent to 191.21 million USD of fertilizers; (4) the weight of fiber and palm shell from crude palm oil extraction process is 7.13 million tons; equivalent to 476.85 million USD of fertilizers; (5) wastewater from palm oil mill is 9.62 million cubic meter per year; equivalent to 1.85 million USD of electricity. The total value of using oil palm remains is 919.35 million USD per year.

Keywords: Zero waste management, palm oil production, food security, oil palm, palm oil

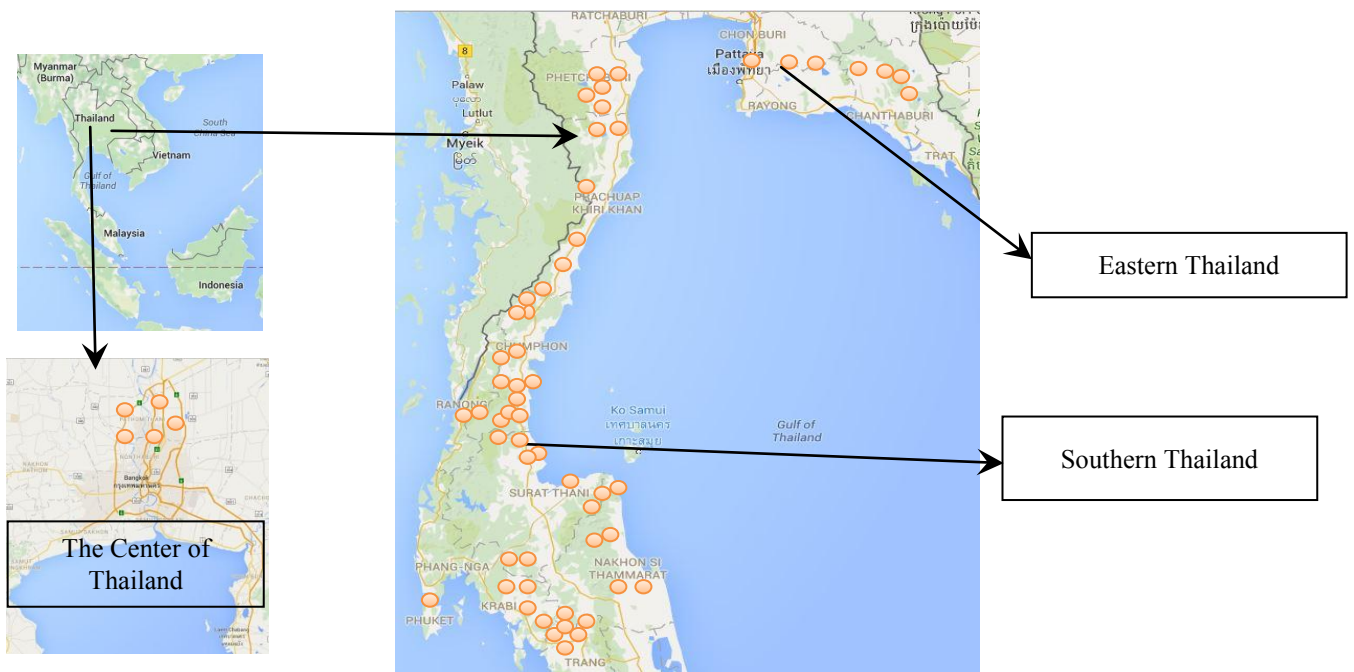
Introduction

In 2014, Thailand was the third largest palm oil producer in the world after Indonesia and Malaysia. Indonesia, Malaysia, and Thailand produced about 51, 34 and 3 % of total oil palm supply in the world respectively [1-4]. Only 12 % of the world's palm oil supply is produced from other countries [5]. The planted area size was extended to 734,400 hectares and the average yield was increased to 18.81 tons per hectare. Palm oil has an important role in the food industry followed by the energy industry, such as biodiesel. In future palm oil will also likely be used as a jet biofuel. In the past, about 85 percent of palm oil was used mainly for consumption, thus its price depended on the price of other cooking oils such as soybean oil. However, currently 15 percent of palm oil is used to produce renewable energy, so its price has fluctuated according to the direction of energy prices. As a result, the fluctuating palm oil price affects oil palm planters' revenues because oil palm is a perennial plant, the planters cannot switch to other crops easily. Therefore, the supply of oil palm is quite stable and its price elasticity is low. In 2015, Thailand had 130,865 oil palm planters, 77 palm oil mills, and 15 refinery palm oil mills [6-8].

Method

Study area

Oil palm planted areas, palm oil extraction mills, and palm oil refinery mills are located in the southern, eastern, north eastern and northern part of Thailand as shown in **Figure 1**. The south included Krabi, Nakhon Si Thammarat, and Surat Thani. The east included Chonburi and Rayong. The center included Pathumthani. The study used the principle of zero waste management and market value approach to evaluate the remains of oil palm through the market price formula of price×quantity (P×Q). The palm oil production produced waste such as debris, leaves, stems, and shell fiber and wastewater; consequently, the study used the solid waste to produce organic fertilizer and the liquid waste to produce electricity as shown in **Figure 2**.



○ Oil Palm Area totally 720,000 hectares

Figure 1 Map of Thailand and the Study Area.

Source: Ministry of Agriculture and Cooperatives (March 25, 2015) and Google Maps (2015).

Using the questionnaire for INQUIRIES and interviews

This research collected information of oil palm development problems in Thailand including guidelines for oil palm development in the future directly by interviewing 30 experts from government sectors, such as the Department of Agriculture and the Department of Agricultural Extension Land Development, and palm oil mills and oil palm planters. With their long-time experiences, these experts provided relatively precise information and the information was analyzed in the study. The interviewees, specialized in the palm oil industry, can predict the future of oil palm and palm oil in Thailand.

Interviewed organizations related to palm oil

Organizations of oil palm plantation consist of growers, grower cooperatives, manufacturers, and the Department of Agriculture, the Department of Agriculture Extension, and the Department Office of Agricultural Economics.

Organizations of the palm oil industry consisted of the Thai Oil Palm and Palm Oil Association, the group of crude palm oil mills, the group of refined palm oil for consumption, the Department of Alternative Energy Development and Efficiency and the group of biodiesel producers.

Policy organizations consisted of the Ministry of Agriculture and Cooperatives, the Ministry of Commerce, the Ministry of Energy, the Ministry of Industry, the Office of National Economic and Social Development, and the Thai Oil Palm and Palm Oil Association.

Marketing organizations consisted of the Department of Internal Trade and the Department of Export Promotion.

Environmental management organizations consisted of the Ministry of Natural Resources and Environment, Pollution control department, the Office of Natural Resources and Environmental Policy and Planning, and the Department of Industrial works.

Oil palm growers and group of oil palm growers

Oil palm growers in the southern part of Thailand: Krabi, Nakhon Si Thammarat, Chumphon and Surat Thani.

Oil palm growers in the central part of Thailand: Pathumthani.

Oil palm growers in the eastern part of Thailand: Chonburi and Rayong.

Oil palm growers in the northeastern part of Thailand: Nakhon Ratchasima and Khon Kaen.

Results and discussion

According to information from oil palm growers and experts, the problems of growing oil palm consisted of:

Zero waste processing and handling of waste

This research aimed at the principles of zero waste management and applied the market value approach to estimate the benefits of all the remains. This valuation method calculated market price by Price \times Quantity (P \times Q). As a result, the value of the waste is 0.92 million USD per year.

Researchers found that the total amount of waste from oil palm plantation is approximately 13.71 million tons, composed of: 1) 7.12 million tons of fiber and palm shell, 2) 3.64 million tons of palm leaves and leaf sheaths trimmed from stems. 3) 2.86 million tons of empty fresh fruit bunches (FFB) 4) 0.09 million tons of palm oil trunks. In the fermentation process, the remains lost about 35 percent of their weight [9], which left approximately 8.91 million tons. Since the market price of this organic fertilizer is 102.94 USD per ton, the value of producing fertilizers from oil palm is 0.92 million USD per year [10-15]. These organic fertilizers can be used instead of imported chemical fertilizers.

Each year oil palm mills created about 9.62 million cubic meters of wastewater. To approach zero waste management, this water can be used to generate electricity. One ton of crude palm oil in the process of crude palm oil extraction provides 0.77 cubic meters of wastewater. One cubic meter of wastewater can produce 34 cubic meters of biogas, which contains 54 - 60 % methane. The methane can be used to generate 2.185 kW hour (kWh) of electricity if a plant can be operated 24 hours per day and operated 300 days per year. Because of the extensive volume of wastewater, the wastewater can be used to produce electricity for sale at a price of 0.09 USD per kWh. This management would benefit our environment. Furthermore, the wastewater from biogas system can be applied as nutrients for oil palm plantations. In conclusion, the estimated value of electricity produced from wastewater is 1.85 million USD as shown in **Table 1**.

Table 1 The value of organic fertilizer and electricity from oil palms and palm oil production.

	Amount			Organic fertilizer price	Value
	Tons	Million tons	After fermentation (million ton)	USD per ton	Million USD
1 Palm leaves and leaf sheaths	3,638,339	3.64	2.36	102.94	243.44
2 Fiber and palm shell	7,126,964	7.13	4.63	102.94	476.85
3 Empty fresh fruit bunch	2,857,729	2.86	1.86	102.94	191.21
4 Palm oil trunks	89,958	0.09	0.06	102.94	6.00
Total Value of organic fertilizer					917.50
5 Wastewater					1.85
The Value of organic fertilizer and electricity from oil palm and palm oil					919.35

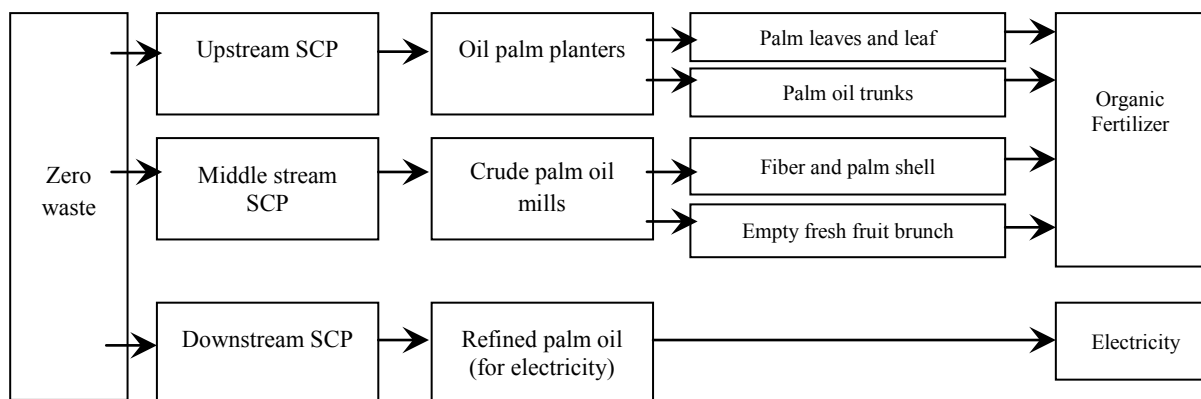


Figure 2 Palm oil production process and remains.

Production

Both agriculturalists and oil palm specialists agree that Thailand must continue to develop the oil palm industry to increase yield, to tolerate dryness, and to be suitable for different areas, in particular areas other than southern and eastern parts of Thailand. Moreover, about 95 percent of agriculturalists and oil palm specialists believe that in the next 2 decades Thai growers will continue to grow palms because palm oil is a raw material for food and biodiesel; in addition, the demand for palm oil and biodiesel is increasing 10 percent per year. Oil palm planters from the northeast area believe that their land can plant oil palms if they use drought-tolerant oil palms. The government must support good oil palms at a reasonable price for oil palm planters. It also needs to research new drought tolerant oil palms. Furthermore, 80 percent of agriculturalists are certain that they will continue being oil palm planters in the future. However, they would like the government to support the breed at rational prices and conduct research for a new drought-resistant oil palm. At the same time, 5 percent of planters are not confident that they can grow oil palms predominantly over the next 20 years as newly planted oil palms are not profitable compared to other crops such as corn, paddy and rubber.

Market

Ninety five percent of oil palm planters in the south need markets to sell oil palm fruit at a fair price, and the market should have a tool for measuring the quality of fruit ripening and oil density. Currently, most mills purchase oil palm fruit without measuring the density of oil. Moreover, they prefer to establish a collaborative of oil palm planters, and their cooperative concept is an effective way to increase their selling oil palm price. Additionally, most planters are faithful, so they would like to sell their products to the cooperative rather than oil mills. However, the systems often fails to follow its own concept.

The food security of the oil palm

Ninety percent of agriculturalists recognize that palm oil can be used as cooking oil and alternative energy. They ensure cooking oil supply will last for the next 20 years. Consequently, it is a great opportunity for farmers to have a stable income. The remaining 10 percent of agriculturalists think that the increase of biodiesel will have an impact on the amount of cooking palm oil [14].

Responsible organization

No organization was responsible for organizing the oil palm and palm oil supply chain from planting oil palm to producing palm oil, whereas Malaysia have a ministry of Commerce and industry controlling the oil palm and palm oil supply chain. Both agriculturalists and experts agree that government should have an organization to control the palm oil system from planting, marketing, processing, food security, energy and environmental management. This organization should enforce a law to control the palm oil plantation system helping oil palm planters to have a sustainable career [15-18].

Conclusions and recommendations

From the results, Thailand's oil palm production still has several problems, and these problems need to be solved by further research and development from the government policy. These major issues consist of 5 topics: land used for growing the crop, oil palm, oil palm processing, marketing, and organization management:

Land used for growing the crop

Farmers plant 304,000 hectares of oil palm on lands that are not suitable, while plant only 276.75 hectares on suitable land. Thus, the yield of oil palms in Thailand is normally lower than both in Indonesia and Malaysia where their areas are more suitable for planting oil palms. Therefore, the Thai government should study which areas are suitable for planting oil palms, in order to provide recommendations agriculturists can follow.

In Thailand, oil palm planters still lack knowledge of oil palm planting and management. For example, before planting oil palm, growers have to select the most suitable area to plant oil palm. The suitable area has these following properties: (1) the soil must be deep, have adequate nutrients, and be strongly acidic, pH 4.5; (2) rainfall must be over 1,300 m³/year, and (3) have suitable moisture. When agriculturalists have insufficient knowledge about oil palm management, they would be likely to grow oil palms in northeastern Thailand where the area is inappropriate for oil palm and an inadequate amount of rainfall. In addition, some oil palm agriculturalists in Rangsit, Pathumthani Province, have raised too narrow plant beds, so the yield of oil palms is low. The government should support the ministry of agriculture and cooperative to do research and development for solving these problem. For instance, the government should provide knowledge and technology to oil palm planters and improve the area for planting oil palm.

Oil palm

Research and development of oil palm in Thailand have been successful for 20 years. However, compared to the oil palm research and development in Malaysia and Indonesia, research and development in Thailand is still behind these countries. Furthermore, the large demand for oil palms is beyond

Thailand's capability. Consequently, most agriculturalists have to import palm oil from foreign countries. In addition, most oil palm planters in Thailand have a small scale plantation, so it is beyond their capability to produce new species of oil palm by themselves [19]. Therefore, the government must enforce all companies to sell good quality oil palms to agriculturalists with a quality warranty. If oil palm seeds sold to the farmer is not profitable, the oil palm sellers must compensate farmers. To support oil palm farmers, furthermore, the government must propagate oil palm farmers to spread more.

Oil palm processing

Due to preferential investment, high concentration of palm oil mills is in only 3 provinces in Thailand, including Chumphon, Surat Thani and Krabi. Therefore, oil palm planters in other regions, where no oil mills are around, have to deliver their oil palm fruits to those 3 provinces. Oil palm planters have to be responsible for logistics costs [20]. Thailand lacks of oil palm experts to advance technology because it does not have a program to generate and educate oil palm experts, or spend a good amount of budget for research and development. Therefore, the government should use tax incentives to support and encourage palm oil mill and oil refinery to build in areas with potential for palm oil plantations.

Marketing

Cooking palm oil price is controlled by the Department of the Internal Trade, the Ministry of Commerce, so the palm oil ceiling price today is 1.24 USD per liter. However, the government does not control the oil palm fruit price; therefore, it allows the oil palm fruit price to fluctuate based on market mechanisms. As a result, the price of oil palm fruit in the market is very low because the crude oil palm extraction plant can set at a low price, while the price of cooking palm oil can stay high [6,7,21]. Therefore, the government should scale up the oil palm ceiling price, since each year the oil price cycle has the oil palm yield less about 4 months (October - January). When the ceiling price extends, farmers will gain benefits from selling the oil palm fruit at a high price in the period of oil palm shortage [22].

Organization management

No government organization in Thailand is responsible for the whole oil palm management system whereas Malaysia has the ministry of Commerce and the industry sector controlling oil palm and palm oil supply chain. Thus, Thailand should have a committee and a government agency to manage the oil palm management system and work with other government agencies such as the Department of Trade, the Department of Agricultural Extension, and the Department of Agriculture. Therefore, without strong cooperation among government agencies, the current policy of the palm oil and the oil palm system is ineffective [23-26]. Thailand has no food security law against the reuse of cooking oil, no environmental management law to encourage oil plants to apply zero waste management, and no regulatory agency to oversee oil palm and palm oil systems. These problems can hinder the management of palm oil in the long term as well.

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