

## Synthesis of Research on the Integration of the Oil Palm Industry within the Context of Thailand and ASEAN Economic Community

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**Abstract:** This study aimed to synthesize and integrate knowledge from research related to oil palm industry within the context of Thailand and AEC. Between 1999-2015, 53 research works from Thailand and other countries were synthesized in accordance with the ASEAN plan of action for energy cooperation. They were characterized in terms of social, economic, environmental and technology aspects. For policy makers, there should be researches for example, increasing the efficiency of oil palm production, building up the sustainability of oil palm in the future. For growers, the problems they faced included loss of income, lack of knowledge on business operation, cultivation and prices of palm oil, palm oil production and competition. Therefore, there should be provisions of knowledge and appropriate techniques in oil palm management including selection of oil palm saplings and planning sites for cultivation, collaboration between groups of growers to build up their knowledge and increase their bargaining power. For the oil palm industry, there are problems related to unreadiness of location and equipment of purchasing points and factories and an environmental impact. Thus, there should be a guideline for purchasing of palm bunch and oil palm by-products and models of the sustainability of oil palm management.

**Key words:** The oil palm industry, Thailand and AEC, research synthetic, planning sites, prices, factories, income

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### INTRODUCTION

Thailand has continuously focused on the development of oil palm industry. In 2014, Thailand Research Organization Network (TRON) by Agricultural Research Development Agency (Public Organization) allocated the budget of 76 million baht to support the target-oriented research in the oil palm industry consisting of demand, supply and supply chain of oil palm and palm oil at the provincial level and attitudes and behavior of those who participated in the palm business; framework, improvement of species, integrated management of palm pests through the basis of the study of the status of palm pests, assessment of high value preservation of palm plantation, cultivation of robust palm species to replace old palm trees and cultivation of supplementary plants, occupational health and safety, child labor and women labor, residue management in palm plantations and utilization (biomass to bioproducts); lifecycle of the production of palm saplings, production process of raw palm oil, oil palm refining, production of biodiesel and related products, management of residue extracting factories, zero waste management and utilization, separation of solid waste sludge before going into clarifiers and improved efficiency of oil extraction rate

of extracting factories, application of available standards to various locations and solve problems and value creation of products from raw palm oil and crude palm kernel oil in continuous industries (biodiesel and glycerol, premium palm oil, supplementary food and oleochemical).

In Thailand's palm oil industry, there are three groups of stakeholders (Anonymous, 2013a), namely, palm growers who constitute the upstream of the palm oil industry, raw palm oil extracting factories which absorb the total oil palm output from growers and constitute the intermediate industry and pure palm oil extracting factories which absorb raw palm oil from palm oil extracting factories for pure refining and sell it to various continuous industries such as ready-to-eat noodles, sweet condensate milk. The production chain of the agricultural sector, especially, oil palm consists of four major parts, namely, producers, processors and packaging producers, distributors and retail shops and consumers. Government agencies, market mechanism and social conditions are influential variables in the production chain which will affect the cultivation of oil palm consisting of economic, social and environmental impacts (Newton *et al.*, 2013). The integration of the oil palm industry is therefore, one way to strengthen the oil palm

industry in the entire supply chain and demand of oil palm. In many countries, there has been integration of comprehensive and efficient oil palm production. As for oil palm cultivation in Asia and the Pacific, the oil palm production consists of the following features (Cramb and Curry, 2012).

Independent oil palm producers who manage their own cultivation, using their own capital, agencies who provide assistance to the oil palm cultivation, specifically set up to assist independent oil palm producers such as capital, technology, knowledge in the oil palm production, cooperation in oil palm production by which companies rent land for oil palm cultivation and co-manage whereas growers will pay the rent and deliver the output to the companies, integration to produce small scale oil palm production between companies and oil palm growers by setting up small groups of oil palm producers who deliver output to processing factories, integration to produce large scale oil palm production between many groups of small oil palm producers, oil palm industry is the integration of oil palm growers and oil palm industry at the regional or national level.

As for Thailand, the integration format of the oil palm industry has not been very clear. As most are small oil palm growers, the oil palm production costs are quite high. Moreover, the Oil Palm and Palm Oil Industries Development Plan (2013-2017) also formulated the strategies to improve the production efficiency and value of palm fruits and products by supporting the integration of production, market, based on potential and strength of growers, agricultural institutes as well as linkage with the private sector to change work behavior from individual work to group work. There are about seven research works in line with the integration of Thailand's oil palm industry, compiled by Thailand Research Organization Network (TRON). The findings of the target-oriented research plan to meet urgent requirement of Thailand's development for oil palm in the budget year 2013 by Agricultural Research Development Agency (Public Organization) revealed that there were only two research works related to the integration of the oil palm industry. Moreover, in 2015 Thailand was joining the ASEAN Economic Community (AEC) to create ASEAN free trade. As a consequence, Thailand's oil palm industry might be affected by trade competitors. Malaysia's palm oil output has potential of high productivity while production costs are lower. Whereas, Thailand's oil palm industry has potential of low productivity while production costs are higher. Palm oil and output from the oil palm industry from competitors, especially, Malaysia, might flow into Thailand and affect Thailand's oil palm industry (Anonymous, 2013b).

Therefore, the research term views that if the knowledge derived from the research related to Thailand's oil palm industry is synthesized and developed as a handbook to formulate the integrated guideline to strengthen the oil palm industry within the context of Thailand and ASEAN Economic Community will contribute to the development of the oil palm industry in its entire system for robust integration. It is crucial to create sustainability of the oil palm industry in the entire system in order to compete in entering the AEC. It also fosters the exchange of knowledge, innovation in the development of the entire oil palm industry (Aujirapongpan and Mettarikanon, 2011). Moreover, the oil palm industry is developed to cover the upstream, intermediate and downstream industries to increase competitiveness in the global market.

**Objectives:** Synthesize research related to the integration of the oil palm industry. Promote participation of the oil palm industry in the entire system in increasing potential, production and sale of oil palm and palm oil under the pressure both inside the country and abroad.

## **MATERIALS AND METHODS**

This study is in the form of synthesis of research works on the oil palm industry related to the strategies to improve the production efficiency and value of palm fruits and products in terms of support to integrate production and market on the basis of potential and strength of growers, grower institutions including linkage with the private sector to change the work behavior from individual work to group work under the development Plan of the Oil Palm and the Palm Oil Industries (2013-2017) in accordance with the principles of sustainable development covering economic, social, environmental aspects as well as other aspects such as technology related to the integration to strengthen the oil palm industry within the context of Thailand and AEC. Research works were compiled between 1999-2015 during the period when Thailand was committed to the ASEAN Plan of Action for Energy Cooperation starting in 1999 until now. Presently, it is during the 3rd APAEC between 2010-2015 with the aim of stimulating investment in energy to drive ASEAN countries to reduce the energy consumption by 8%, increase alternative energy in the region by 15% and drive the ASEAN region to become Asia's alternative energy hub (Anonymous, 2015).

This study is based on the research work related to the strategies to improve the production efficiency and value of palm fruits and products in terms of support to

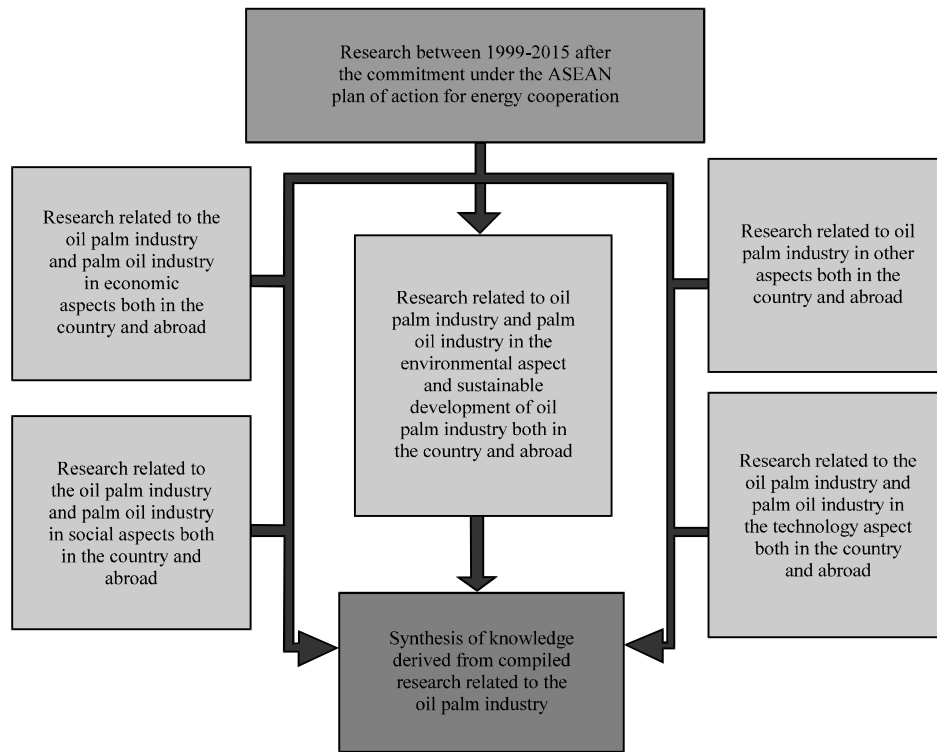


Fig. 1: Conceptual framework of the study

integrate production and market on the basis of potential and strength of growers, grower institutions including linkage with the private sector to change the work behavior from individual work to group work under the Development Plan of the Oil Palm and the Palm Oil Industries (2013-2017) focusing on management to integrate the oil palm and palm oil industries in view of competitiveness and support the integration of AEC in 2015. The research works were conducted between 1999-2015 with the conceptual framework as illustrated in Fig. 1.

The study of the integration of Thailand's oil palm industry within the context of Thailand and ASEAN Economic Community is conducted according to the following methodology.

Set up criteria to select documents by which the researcher sets up clear criteria to select documents and topics for the analysis. The study covered the period of the year of publication or records of the research content as major criteria to select documents, that is, between 1999-2015 by referring to ASEAN Plan of Action for Energy Cooperation (APAEC) occurred under the integration of the ASEAN Economic Community of ten member countries and related to the strategies to improve the production efficiency and value of palm fruits and products in terms of support to integrate production and

market on the basis of potential and strength of growers and grower institutions as well as linkage with the private sector to change work behavior from individual work to group work under the Development Plan of the Oil Palm and Palm Oil Industries 2013-2017.

Compile concept and research works related to the palm industry between 1999-2015, research works in accordance with the strategies to improve the production efficiency and value of palm fruits and products in terms of support to integrate production and market on the basis of potential and strength of growers and grower institutions as well as linkage with the private sector to change work behavior from individual work to group work under the Development Plan of the Oil Palm and Palm Oil Industries 2013-2017 and research works related to the adaptation of the oil palm and palm oil industries to enter AEC in parallel with Foreign research works that integrate cooperation to foster potential in the production of oil palm and palm oil as comparative case studies. The criteria for the selection of research works were as follows.

Research works conducted and finished between 1999-2015. Research works related to the integration of the oil palm and palm oil industries in Thailand, covering economic, social, environmental issues as well as others such as technology related to the integration of the knowledge of the oil palm industry.

Research works related to the adaption of the oil palm and palm oil industries in entering AEC and other research works related to the strategies to improve the production efficiency and value of palm fruits and products between 1999-2015. Research works related to the integration of the oil palm and palm oil industries in ASEAN countries between 1999-2015.

Synthesis of knowledge from all research works related to the integration to strengthen the oil palm industry within the context of Thailand and ASEAN, Economic Community. Summary and linkage of knowledge use process and method of synthesis of research work by Cooper in order to acquire the information on the current status of Thailand's oil palm industry, gaps, problems and obstacles of conducting research from the past till the present to serve as future research direction.

## **RESULTS AND DISCUSSION**

From the study of the concept and all related research works covering economic, social, technology and environmental issues and sustainable development of oil palm industry and other related aspects, the issues from the research can be summarized as follows. Research works from domestic and Foreign agencies are different in line with objectives of the development and timeframe. Past research works or those before 2007 dealt with technical research or research that sought suitable implementation of growers in terms of social and scientific dimensions. It was the period when the production of biodiesel was the topic of interest and many farmers changed their profession into oil palm growers. At the beginning, the plantations were mostly in the South. Most research, therefore, were case studies from Southern provinces such as Krabi, Chumphon and Surat Thani, etc. As the geography and the climate of the region accommodated the growth of oil palm, oil palm was widely cultivated. After 2007, the situations of alternative energy and the problems of the environment intensified both in Thailand and in other oil palm producing countries. As a result, they turned their interest to the research related to the emission of greenhouse gas, lifecycle analysis, the development of oil palm industry to enter the alternative energy system and environment and increasingly sustainable development of oil palm industry. Moreover, Foreign research works, especially, major oil palm producers in the global market such as Malaysia, Indonesia, Brazil, etc., focused on the policy-based research including the environment and the sustainable development of the oil palm industry, the production of oil palm in order to enter the alternative energy system such as biodiesel. Therefore, the synthesis of the knowledge

derived from all research works compiled by the researchers can be used as a guideline to strengthen the oil palm industry within the context of Thailand and ASEAN Economic Community as follows.

**Knowledge on the oil palm as synthesized from related research works:** All research works that the researcher compiled between 1999-2015 which was the period when Thailand was committed under the ASEAN Plan of Action for Energy Cooperation operated, since, 1999 until the present. It is currently under the 3rd APAEC (2010-2015) with the aim of stimulating investment in energy, driving ASEAN countries to reduce energy consumption by 8%, increasing the consumption of alternative energy in the region by 15% and driving ASEAN as the hub of alternative energy in Asia. The research findings revealed that there were 53 research topics that fit the criteria. The researchers divided the research works according to the principles of sustainable development of oil palm industry under the economic, social, environmental aspects and other aspects such as technology related to the integration of oil palm. The research findings revealed that currently, most research works focus on the study and development of production process in parallel with environmental protection for sustainable production. The 53 research topics covered three main issues which are important components of the oil palm industry namely the upstream production such as individual growers and groups of growers, the intermediate production such as entrepreneurs of palm oil processing and extracting factories and the downstream production such as policy-making and planning agencies of the development of the oil palm industry. Knowledge crucial to the three groups of composition is as follows.

**Growers and groups of growers:** Growers and groups of growers are the crucial upstream oil palm industry. The 53 compiled research works revealed that most research placed importance on growers. Especially, between 1999-2007 in Thailand there were many research works to create important knowledge for those who turned to oil palm cultivation. The synthesis of major issues beneficial to growers was as follows.

Most oil palm growers were villagers with limited academic knowledge. Many research works revealed that oil palm growers in many areas, especially in the South and the Northeast, finished their primary education, aged between 40-50 years old with the plantation sizes between 10-100 rais per person. They operated oil palm plantations based on experience from planting other crops and they widely used chemical fertilizers, especially in the past before the advent of the social issues on the

environment. Generally, growers used 15-15-15 and 13-13-21 chemical fertilizers due to easy availability, past experience of farming and the use of chemical pesticides. Grower's decision to choose to cultivate oil palm should take into account planting factors, especially, the conditions of the areas and appropriate management. Research on the efficiency of palm plantation management revealed that growers should select planting areas (types of soil) appropriate to the growth of oil palm, select Tenera hybrid species with potential of high yield, select robust palm saplings to reduce the loss of plantation plots, use suitable cultivation system and plot planning such as the plot of 9×9×9 m, arrange oil palm plots to be exposed to maximum sunlight during the growth peak and attention paid to fertilizers by mixing chemical fertilizers with organic fertilizers and biofertilizers in appropriate portion according to specific soil conditions and the environment of plantations. Growers should also regularly note each process of plantation management such as income, expenditure, ratio of the use of fertilizers, use of laborforce in order to compile important information for analysis to solve problems or improve the next cycle of production process for maximum efficiency.

In the past, most growers were individual growers with hardly any integration to increase output. Most growers lived in the South such as Krabi, Surat Thani. The study of the Office of Agricultural Economics revealed that actually nearly all growers wanted integration and wanted the government to invest in palm oil extracting factories in local areas or in areas with large concentration of plantations to reduce transport costs and provide advice on correct knowledge. They wanted financial institutions to invest with them, so as to strengthen them. Research on the survey of plantation areas revealed that oil palm growers could be divided into 3 groups according to their readiness namely large plantations (over 200 rais) by which they could hire regular experts to take care of their plantations, mid-sized plantations (over 50-200 rais) they could have their own household management and small plantations (<50 rais) with growers who hardly had any knowledge or experience in oil palm. This coincided with the research works of other researchers who recommended that growers should seek knowledge and understanding of production process from supporting experts and should integrate themselves to increase their role in negotiations such as output prices, etc.

Oil palm growers should focus on replanting to replace old oil palm plantations. The research by Krirkchai (n.d.) revealed that the oil palm cultivation to support the industry should start by replanting new oil palms to replace old oil palms with 20-30 years of age. The

important factor in considering replanting was the height of the palm tree as it affected the harvest which would be more difficult with the advancing age. Growers should use the replanting system by planting 100% palm saplings when they were 12 months old, then starting to cut down 50% of the old palm trees, after 6 months of transplanting and cutting down 100% after 24 months of transplanting or planting 100% palm saplings when they were 18 months old, then starting to cut down 50% of the old palm trees and then cutting them down 100% when the replanted palm saplings reached 24 months old. Subsequently, growers could collect output from both new and old plantations which would double the efficiency than replanting the whole plantations of new palm trees. This coincided with the research work of Sombat which revealed that to increase efficiency in oil palm cultivation and reduce investment risk, growers should diversify cultivation areas such as oil palm cultivation with other plants or cattle raising in parallel. Growers should select oil palm species that suit local conditions, study in detail palm species from relevant officials. The research by Juntarumporn (2012) revealed that oil palm species that was important to growers in the South was oil palm species Surat Thani two which was improved by Oil Palm Research Center, Surat Thani Province. The species is strong and can grow well in sandy soil on the beach and Tenera hybrid species which is the hybrid between DURA and Fisifera, resulting in the hybrid that suits Thailand's conditions, yielding high oil percentage, higher output per location, making the trees shorter, resistant to dryness and disease. Moreover, growers should conduct analysis of soil quality and palm leaves to fit the ratio of the use of fertilizer according to needs of the plant, use household labor than hiring outside labor and if necessary lump-sum hiring such as applying fertilizer or harvesting.

Many research showed the oil palm cultivation related to production factors and marketing. The main factor that determined the grower's decision to sell was the convenience in transporting output. Growers focused on selling their output to the purchasing points, the system of which consisted of market costs, depreciation, salary and labor costs, being main factors that the growers would lose. Most growers would follow price situations, receive news on output prices and production factor costs at a high level. Research works in 2010 revealed that the strategies that reduced the risk of the grower's loss of money were the following: reduce unnecessary expenses such as use of household labor instead of hiring or if necessary use cheap labor, reduce the use of fertilizer if cultivated in already rich soil and combined use of organic fertilizer and biofertilizer to

improve soil quality, taking into account their own old soil condition. The research work in 2012 revealed that the combined use of chemical fertilizer and organic fertilizer would change the chemical quality in the soil, increasing the volume of organic substance to the soil instead of using only chemical fertilizers in the same soil. To increase the efficiency of organic fertilizer in oil palm cultivation, organic fertilizer was used with groundcover, resulting in increased soil nutrients. If possible, growers should follow the advice of the Department of Agriculture, so that, growers themselves would receive more income than use only chemical fertilizer.

At least two research demonstrated that the production costs of old growers were higher than those of new growers. Old growers with long history of oil palm cultivation usually adhered to old practices as they believed in their own experience and did not wish to change their production system according to academic principles of supporting agencies. The research were in line with the research work on the acceptance of oil palm production technology. The findings revealed that most growers in the South had experience in oil palm cultivation for at least 10 years. They preferred oil palm species from Malaysia because they were confident in the long-standing quality with easy availability. Relevant factors on the acceptance of new production technologies included age of growers, income from oil palm output and attitudes of growers on technology from experts. Growers were not confident in the ability of experts if the latter failed to demonstrate or show the results. Technologies directly related to oil palm cultivation included technology of oil palm species, technology of land preparation, technology of plantation management, technology of weeding and technology of transport of output. The most accepted technology by the growers was technology of weeding as growers faced the long-standing problems of weeds in their plots, affecting the quality of output. The technologies that were not very well accepted and by which the growers did not practice correctly were the technology of plot management and the technology of fertilizers. The main factor affecting the acceptance of technology of growers was funding. If growers had access to funding, they would be willing to participate in activities or accept technology by trying it.

Research on grower's logistics costs revealed that the grower's logistics system could be divided into 3 main systems, namely, material management, harvest and handling of palm fruit, transport of output, communication with entrepreneurs operating purchasing points or output buyers. The 3 systems were found that

in the South, it was popular to hire laborforce, resulting in growers receive less compensation in each production cycle.

New growers were in the Northeast. Most did not receive training in oil palm cultivation or knowledge transfer from experts. Subsequently, growers did not have expertise in oil palm cultivation and did not have correct knowledge and understanding of plantation management and use of fertilizers. The research in 2014 clearly demonstrated that new growers should conduct comprehensive study of business operation of oil palm plantation including the knowledge on cultivation, maintenance, marketing, distance of transport of output to market. Importantly for growers especially in the Northeast which was a new area, there should be consideration of appropriate land for cultivation including type of soil, climate, water sources, risk from natural disasters. If the oil palms were planted in inappropriate areas, growers would risk losing their money and increasing unnecessary production costs. If possible, selection should be made for areas not far from market to reduce the transport costs of output.

There were at least three research works on the emission of greenhouse gas from the grower's oil palm cultivation. For example, the research of Arun showed that the growers with the plantation areas of approximately 25 rais would emit the greenhouse gas from the use of fertilizer of approximately 9.394 tons equivalent of carbon dioxide per year and emit the greenhouse gas from transporting fresh palm bunches to the factories approximately 0.154 tons equivalent of carbon dioxide per year. Therefore, growers must have good plantation management for higher output together with the reduced use of chemicals to reduce the emission of greenhouse gas. The guideline of oil palm plantation management to reduce the emission of greenhouse gas studied by the Office of Agricultural Economics in 2013 revealed that the oil palm process emitting the most of greenhouse gas per production of 1 kg of fresh palm bunches was the cultivation. It consisted of transporting palm species and use of fertilizers and chemicals, emitting the greenhouse gas of 0.04390 kg equivalent of carbon dioxide or 86.88%. Therefore, growers should select good palm saplings certified by Department of Agriculture and select species suitable to the plantation areas, harvest ripe palm output as determined to reduce the loss of raw palm oil, transport full production factors to reduce fuel consumption and growers should have palm leaves and nutrients analyzed every year and should use appropriate fertilizers according to the age of the palm trees and in appropriate quantity.

**Entrepreneurs of oil palm processing and extracting factories and oil palm's continuous industries:**

Entrepreneurs of oil palm processing and extracting factories and oil palm's continuous industries which constitute the intermediate industry are crucial to the oil palm industry. They affect growers and the country's economy and environment. The 53 compiled research works showed that in the beginning or the first phase of ASEAN Plan of Action for Energy Cooperation (1999-2004) the research did not focus on the development of knowledge for entrepreneurs, oil palm processing and extracting factories or other continuous industries. It was the last phase, since, the ASEAN Plan of Action for Energy Cooperation (2005-2009) when researchers put more emphasis on the operation of factories probably due to the increased demand of oil palm, production process affecting the environment and economic competition of each country. Many research were conducted to develop the knowledge to entrepreneurs, oil palm processing and extracting factories and oil palm's continuous industries. The synthesis of the main issues beneficial to entrepreneurs, oil palm processing and extracting factories and continuous industries of the oil palm was as follows.

Oil palm plantations constituted a business that growers and entrepreneurs took interest on a continuous basis. The issue of alternative energy was also continuously promoted by the government, so, new industries related to oil palm output increased.

For the entrepreneurs interested in setting up purchasing points of raw oil palm from growers or setting up factories for oil palm's continuous industries, suitable locations should be considered such as the setting up of the purchasing points to purchase oil palm and the collecting system of entrepreneurs or cooperatives. There should be assessment of suitable locations and operation to gather oil palm through the purchasing points of a branch or a headquarter, so that, the cooperatives or the purchasing points might have more profit.

The main issues that the entrepreneurs should take into consideration in purchasing oil palm output which was in a study in 2010 were purchasing criteria by which the entrepreneurs should consider only the ripeness, so that, growers could easily understand; purchasing prices; time and place for delivery should be close to most growers; on-time payment, fairness in selecting grades. Moreover, factory executives were satisfied with the selection and the screening of quality using the sole criteria of ripeness as good quality palm was assured to enter the factories. Therefore, cooperatives or entrepreneurs must set up clear criteria of quality screening and additional prices to growers according to the output quality. The executives should formulate the policy to promote clear selection process of output and foster incentives to members, publicize, provide academic

services to the local growers and importantly the precision of the scale, the increase of purchasing points and the setting up of a harvest team of the purchasing points. As for the oil palm extracting factories, executives should formulate the policy to support and create incentives to customers and consider the advantage of the transport distance.

For entrepreneurs or cooperatives with many members, there should be a guideline of combined management to change grower's behavior as in the study by Nissapa (2001). The study findings revealed that there were 3 main factors that made the members change their behavior, namely, equality of members by which any activities should be organized, so that, members could benefit or could widely and equally gain access to information and news; operation efficiency, so that, members could make joint decisions, sustainability by which members would accept the sustainable management and were confident in oil palm output, so, they were willing to participate in the activities of the group or agreed with the operation of entrepreneurs. Moreover, in case the entrepreneurs used the technique of combined management with members would result in the change in the behavior and relationship under the economic and social aspects as well as grower's attitude. The good combined management must take into account suitable management and role of stakeholders in the entire system. If possible, participation should be promoted between members, the private sector, the government sector, especially, the members who were long-time residents in the community. Members should be driven to have more knowledge and experience, more self-governing role of members and promote the ability for income generated from other sources as appropriate.

Many Foreign research works demonstrated the importance of producers in the continuous industries of oil palm. Producers constituted a crucial component of the system, being the drivers of the mechanism to make farmers turn into oil palm cultivation and pay attention to the quality of the output. At the level of entrepreneurs, there should be cooperation or promotion to drive the cooperation between growers, industrial plants and local administrative organizations to show their responsibility towards the society and the environment. Good entrepreneurs should cooperate with community or private sector development organizations to develop areas for cultivation, purchasing space as well as allocate budget from financial agencies for continuous development of the oil palm industry.

Many research studied the reduction of the impact on the environment of the oil palm industry as the industry emitted the greenhouse gas into the environment from cultivation till the oil palm entered the industrial plants. When the global development turned to the

importance of the environmental problems under the ASEAN Plan of Action for Energy Cooperation (2010-2015), Thailand and other oil palm growing countries turned to many environmental research works, especially on entrepreneurs, industrial plants as the production process discharged a lot of waste into the environment such as wastewater from palm oil extracting factories. The research findings revealed that the wastewater should enter the closed wastewater treatment system for fermentation, so as to create biogas. It would reduce the amount of wastewater and the emission of greenhouse gas by over 50% of the production. According to the study on the emission of greenhouse gas from industrial plants, the emission of greenhouse gas from palm oil extracting factories accounted for 95% from wastewater of the factories. Apart from the wastewater from factories, the use of empty palm bunch for fermented fertilizer was a good alternative. Fermented fertilizer could be used in palm plantations to reduce the emission of greenhouse gas and preserve natural resources at the same time. With the production of 1 ton of fermented fertilizer from empty palm bunch and decanter sludge, the greenhouse gas was created for 381 kg equivalent of carbon dioxide. It would reduce the use of chemical fertilizer, improve the soil quality and prevent the soil erosion. In summary, the damage and the impact on the environment from the oil palm extracting factories could be reduced by producing the waste into combined energy or with correct management. Currently, most palm oil extracting factories did not have a chimney to separate gas which was crucial in reducing greenhouse gas. The emission of greenhouse gas from the production system of combined heat energy might not be predictable but the production system of combined heat energy could reduce the eutrophication phenomenon, acid rain and toxic substances or waste sludges. The research works coincided with the research of Man Kee Lam that wastewater from the oil palm extracting factories could be used to produce potential alternative energy. There should be airless treatment to disintegrate organic substances. Moreover, it could produce different types of alternative energy. It was therefore, the current strategy for sustainable development with zero waste which was significant to protect the environment in Malaysia.

More than 3 research works on the prototype to operate the oil palm industry for sustainable development dealt with the following: operation of Malaysia and Indonesia which are important ASEAN members in the global oil palm market due to high production volume compared to other countries in the world. Most research works in Malaysia and Indonesia focus on lifecycle analysis of products from oil palm. The study in 2013

revealed that the inspection of the sustainability of the oil palm industry could use the principle of carbon footprint to assess the entire lifecycle of the products as they could reflect the awareness of environmental problems from oil palm growers, oil palm processing industry and consumers. The important information consisted of direct information affecting the emission of the greenhouse gas from the oil palm industry such as land use, energy use, waste management and impact from the oil palm industry, the information of the palm oil extracting factories and palm oil refining factories accompanying the consideration such as energy use, waste treatment within factories and impact from the production activities within factories and the information by the relevant industries such as from the food industry to the consumers of palm oil or products with oil palm as component.

Researchers studied, the emission of greenhouse gas from oil palm extracting factories in Thailand with 14 participating palm oil extracting factories to assess the emission of greenhouse gas from production process. They then compiled the relevant information for calculation which accounted to 34.6% of the production capacity of raw palm oil in Thailand. The findings revealed that the emission of greenhouse gas from the wet extraction process, deriving from using some raw materials for production such as chemicals, energy, transport and wastewater treatment from production process, the emission of greenhouse gas from the 14 factories amounted to the average of 1,198 kg equivalent to carbon dioxide per 1,000 kg of palm oil. The emission of greenhouse gas mainly came from oil palm cultivation and harvest of palm bunch as well as wastewater treatment. In 2009, the extraction of raw palm oil in Thailand caused the emission of greenhouse gas approximately 1.62 million tons in line with the research of Charongpun Musikavong where the emission of greenhouse gas from raw palm oil extracting factories of the wet type derived from raw palm bunch and wastewater treatment. Greenhouse gas was emitted both from wet extracting factories with the biogas collecting system and wet extracting factories without the biogas collecting system. Therefore, at the levels of entrepreneurs and industrial plants, there should be calculation on the emission of greenhouse gas, development of the technology in greenhouse gas management and importantly, management of the sources of greenhouse gas.

According to the research work in 2009, most biodiesel factories at the communal level employed used oil as raw material in production which made it difficult to produce biodiesel with quality and standards. So, the production was more suitable for the community's own use and was specifically used with agricultural machinery.



Commercially viable biodiesel should be biodiesel from oil palm. Biodiesel producing factories for commercial purpose in Thailand had raw palm oil as raw material with potential to produce biodiesel, both in terms of quantity and quality, suitable to produce biodiesel with quality and features determined by standards.

Foreign research works revealed that the palm oil industry was one of the leading industries in Malaysia who produced palm oil at the average of 13 million tons a year. Currently, Malaysia uses the strategies appropriate to the country's operation, that is, provision of biomass energy from the oil palm industry to produce hydrogen energy with at least 40% of Malaysia's demand of energy which will reduce the dependence of fossil-based energy.

**Policy-making and planning agencies on the development of the oil palm industry:** Policy-making and planning agencies on the development of the oil palm industry as an upstream industry are the drivers and mechanisms that stimulate the sustainability of growers and groups of growers and economic competitiveness at national and international levels. Agencies at the policy level will directly affect growers and industrialists and the country's economy and environment. The compiled 53 research topics revealed that in the beginning, the ASEAN Plan of Action for Energy Cooperation (1999-2014), on the part of Thailand, the research did not focus on the policy and plan of the industrial development but would focus at the operating level. Until the present day with environmental problems and competition in the economy, competing oil palm countries turn to focus on solving problems and planning the development from the beginning until the implementation. Therefore, since, the ASEAN Plan of Action for Energy Cooperation (2005-2009) and ASEAN Plan of Action for Energy Cooperation (2010-2015) or until nowadays, researchers turned their interest to create knowledge for policy-makers. What was obvious was that most research works of ASEAN countries such as Malaysia and Indonesia, responded to the demand of top executives and focused on the development of oil palm production from the level of those who formulated the policy. Based on the synthesis, the main issues benefitting the agencies at the policy and planning levels on the development of the oil palm industry revealed the following.

Past research works in 2001 which was the period when the ASEAN FTA was first studied dealt with the impact of ASEAN FTA on Thailand's oil palm industry. When the agreement under the ASEAN FTA tariff rates came into effect in 2003, the oil palm industry would be negatively affected, especially oil palm growers. But if

they adapted themselves to keep abreast with the situations and urgently implemented the oil palm development plan, the impact on the oil palm entrepreneurs would be reduced. Those who formulated the policy and plan of the oil palm development should divide growers into 2 types namely general small growers including growers in cooperatives and industrial estates and the private sector operating plantations in the form of companies in order to receive information benefitting the strategy formulation, suitably and directly deal with the complete implementation of ASEAN FTA. The research of the Office of Agricultural Economics in 2002 revealed that growers wanted to have their own factories and wanted to enter into joint venture with the government to build the factories. The study on the acceptance of the investment in setting up oil palm extracting factories revealed that most growers understood business operation only a little and they did not know the details of operation, the government regulations and laws. Therefore, the government agencies should clearly elaborate on the details of the joint venture programs in order for the growers to accept the joint venture.

Many research works showed the research results of the demand of growers and groups of entrepreneurs in the industry to the government agencies or those at the policy level on the national development of oil palm for sustainability. For instance, the research in 2004 found that growers sought the government's assistance in production factors, price control of output, support of integration as well as continuous support of academic knowledge. Related scholars or agencies should systematically promote the dissemination of knowledge and new technologies from planting to harvesting, support the integration of oil palm growers by setting up the group's purchasing points, selling production factors to members, conducting campaign to collect samples from soil and oil palm leaves for analysis of the need of nutrient to reduce grower's production costs and encourage the production of oil palm saplings to meet the need of growers. The growers would be able to use good species, would not grow oil palm tree taken from the foot of the tree. Important issues found in many research works were that related agencies should take care of growers. Moreover, the government should clearly specify the protection of the oil palm profession to encourage growers to invest. The government might introduce price guarantee or clearly set up the prices, determine the standard of the purchasing price of raw oil palm output according to the percentage of oil in the fresh palm fruit or according to weight as consideration criteria, announce daily prices or perhaps set up an agency conducting the study and research on oil palm and provide advice on

plantation management to growers and continuously focus on the research and development of knowledge and technology related to oil palm plantations.

Research work in 2005 on the consumption and export of oil palm in Thailand revealed that the factors affecting the change in the domestic demand of palm oil were raw palm oil prices, soybean prices and the growth rate of the industries using palm oil as raw material. The factors affecting the change in export of palm oil were raw palm oil prices, Foreign exchange rate, remaining stock in the country and Foreign palm oil prices in the Malaysian market. The factors affecting the areas of oil palm harvest were raw palm oil prices and rubber prices. The factors affecting the palm oil output were the current palm oil prices and past palm oil prices. The factors affecting the import of palm oil were the growth rate of the industries using palm oil as raw material and Foreign palm oil prices in the Malaysian market.

Research works on the study of the guideline to increase the efficiency in the oil palm production revealed that currently there were new oil palm growers and the expansion of the size of the palm plantations more than in the past by 62.07% of the total new growers. The issues that the growers were interested in and the knowledge obtained from scholars that the growers implemented were mostly maintenance, use of fertilizers, harvest and protection against palm pests. Therefore, policy-level agencies should develop the standards of the production and quality of oil palm output by disseminating GAP to growers, recommending quality species and continuous training as well as setting up curriculum in line with grower's needs at a particular time. The research works also coincided with the research work in 1997 in which the government should support and assist entrepreneurs in the oil palm industry by providing revolving fund for lending at low interest rate, promoting at least one group of oil palm growers in any province to operate comprehensive oil palm business including the buying point of fresh fruit bunches, the selling of agricultural production factors to strengthen the growers and entrepreneurs in the entire system.

There were 2 research topics on the study of the structure of oil palm market. The structure of the oil palm market in the Northeast which is the new area for oil palm cultivation, especially in Nong Khai and Bueng Kan is still an imperfect market. The sellers (growers) are considered a market with monopolistic competition with many sellers. The buyers (middlemen) are a market with few buyers. Therefore, related agencies should promote the knowledge in considering appropriate area for

cultivation. As oil palm is a new crop in the northeast, most growers still lack knowledge and understanding in considering the suitability in various aspects.

Since 2007, there have been many research on the study of technology suitable to oil palm cultivation for Thai growers. Most research results showed that growers still lacked knowledge and experience in making use of technology. The main factor having impact on the grower's acceptance of technology was funding. If growers received funding, they would be willing to participate in projects or implement the technology. Therefore, the relevant agencies should disseminate knowledge or impact on the use of technology for the grower's understanding, especially technology related to the use of fertilizers and grower's production costs.

Most Foreign research works focused on the level of those who formulated the policy to develop oil palm. The research work that studied the impact of oil palm on the environment revealed that for the oil palm cultivation in large producing countries such as Malaysia and Indonesia, oil palm is a plant which is much in demand worldwide. In the past, there was widespread forest encroachment for oil palm cultivation, especially in countries in Southeast Asia. The sole cultivation of oil palm not only destroyed the ecosystem but also reduced the diversity of plants for food. It also caused pollution such as the emission of greenhouse gas. Therefore, currently, many countries pay attention to the encroachment of forest or public land in order to change the utilization into oil palm plantations. Presently, millions of rais of land in Malaysia were seized and the utilization of land was increased into oil palm plantations. Recommendations were therefore, put forward that the government agencies, the private development organizations and other relevant agencies should join hands in preventing the destruction of the ecosystem derived from oil palm cultivation. Their efforts should include the following: determining the areas suitable for oil palm cultivation; accelerating the cooperation between growers, industrial plants and local administration agencies to show responsibility towards the environment, by issuing rules and regulations to preserve communal forests, use of income from the sales of goods from oil palm factories to rehabilitate the environment in the community and promote environmental-friendly production of agricultural products including crops, cattle and fishery to raise grower's awareness and understanding of global warming from the agricultural sector.

Many research works abroad focused on the study of the guideline to create sustainability to the future oil palm industry. In 2009, there were at least 2 topics on the development of research namely oil palm-based bioenergy recognized worldwide as the most efficient way to reduce global warming and promote sustainability. Malaysia was an example of the use of biomass as a source of alternative energy to other countries in the world with the great amount of biomass raw materials. There were scientific research results that supported the fact that palm oil had the most nutrient value in the world. With the suitability for consumption and reasonable prices, it was in continuous demand worldwide. Therefore, sustainability should be created for future oil palm industry by agencies at all levels such as decision-makers, government agencies, private organizations, oil palm entrepreneurs and oil palm growers. Policy should be formulated to support the use of biodiesel to foster incentives for oil palm cultivation. NGOs should provide advice on the areas suitable for oil palm cultivation. Laws should be enacted that relate to the development of oil palm industry and budget allocation from financial agencies for the continuous development of the oil palm industry. Moreover, according to the research work on the study of sustainability in the production of palm-based biodiesel in Thailand, the findings revealed that the lifecycle analysis showed the lower impact on the environment by biodiesel compared to diesel. Energy security and environment would depend on various factors such as efficient management of oil palm bunch of oil palm extracting factories and the change of future land use having impact on the long-term energy security and sustainable production of biodiesel. The standard certification would increase the long-term production security. Therefore, policy should be formulated to support growers to be eligible for GAP standard certification to increase oil palm quality and efficient waste treatment such as the use of residue from oil palm to produce biomass energy to be used in the palm plantations.

Oil palm is crucial to the production of biodiesel. More than three research topics dealt with the study of the production of oil palm to produce biodiesel in Thailand, ASEAN and Southeast Asia. The study findings revealed that there were 3 main factors to create sustainability in producing biodiesel from oil palm namely setting up of standard or regulation in the oil palm cultivation at the domestic and international levels to prevent the destruction of natural resources and the environment and prevent the loss of the carbon sink from oil palm cultivation, mediation or opportunity provided for the concrete land right to prevent encroachment of preserved area for oil palm cultivation and there should be distribution to the communities, so that, they could efficiently produce biodiesel fuel for local consumption

and development of technology in the production of biodiesel to encourage the widespread use of environmental-friendly energy.

Reduction of the greenhouse gas from the palm cultivation is a topic that is increasingly studied and researched now both in Thailand and abroad. Many research works clearly pointed out that the government should develop the setting up of database of the emission of greenhouse gas from the agricultural sector in other main agricultural products on a continuous basis and encourage growers to become aware of and understand global warming derived from the agricultural sector. Each country wishing to inspect the sustainability of the oil palm industry can use the principle of the carbon footprint to assess the lifecycle of the entire product cycle as it can reflect the awareness of the environmental problems from oil palm growers, oil palm processing industry and consumers. The use of carbon label consisted in inspection, monitoring and assessment of operation on a regular basis. Knowledge should also be provided on creation of value added from the products or waste derived from the oil palm industry to provide the oil palm industry in its systematic operation and support the policy development to develop the oil palm industry for sustainable continuity. Moreover, the government should support the study and research on the emission standard of greenhouse gas of other plants to formulate measures or guideline to reduce the volume of the emission of greenhouse gas and improve management of the agricultural system for increased efficiency.

They divided the main stakeholders in the industry into three groups namely growers and groups of growers, entrepreneurs of oil palm processing and extracting factories and continuous industries of the oil palm and decision-making and planning agencies for the development of the oil palm industry in combination with the study of relevant documents which can be summarized as follows.

#### **Current situation of Thailand's oil palm industry and Thailand's context after the integration of the ASEAN Economic Community:**

Nowadays, the oil palm industry relates to the agricultural sector and other continuous industries. Oil palm is considered an economic crop crucial to the country's development. The oil crop also tends to grow on a continuous basis. Thailand was ranked third after Indonesia and Malaysia as the world's main producer of palm oil in 2012 and the trend was 5-7% of higher growth compared to the previous year. It was partly because the Thai Government implemented the oil palm strategy between 2008-2012 in order to drive the growers to expand their oil palm plantations and increase output to meet the 25% alternative energy strategy in 10 years (2012-2021) with the aim of replacing fossil-based diesel for 5.97 million L/day by 2021.

Oil palm is an important industry whereas Thailand's yield per rai is quite low, compared to Malaysia. Production costs are also higher. As the structure of most of Thailand's oil palm production consisted of the following: approximately 60% of smallholders, 20% of the plantations of companies and 10% of cooperatives/industrial estates. Therefore, Thailand could not efficiently plan production and control production costs. The integration of AEC in 2015 would affect Thailand's oil palm industry. For example, the tariff reduction of palm oil under AEC in 2010 would be 0%. Thailand still reserved import under Public Warehouse Organization (PWO) similarly to the import under AFTA in practice to solve the problem of the shortage of raw palm oil. In the past year or two, the government by PWO imported palm oil from Malaysia intermittently which greatly affected the oil palm growers because raw palm oil from the neighboring countries was cheaper than the Thai counterpart. The reason was perhaps partly the government's policy that determined price guarantee of fruit bunch for domestic growers, resulting in higher production costs of raw palm oil for raw palm oil extracting factories in Thailand than in Malaysia. Moreover, palm cultivation in Thailand is smallholding system and there is fewer development of palm species in Thailand than in Malaysia. Production costs in Thailand are therefore, higher than in the neighboring country. So, the import tariff reduction of palm oil inevitably affects the entire system of the production of oil palm and palm oil including the upstream, intermediate and downstream industries, especially oil palm growers, raw palm oil extracting factories, pure palm oil refining factories and domestic consumers. They have to face the problem of periodic shortage and high prices of pure palm oil as the Ministry of Commerce set the policy of not allowing the pure palm oil to raise the prices according to the increased production costs.

Moreover, the opportunity for Thailand to develop palm species to compete with Malaysia and Indonesia may be more difficult. As the research demonstrates that most Thai growers are smallholders with the lack of management and efficient policy whereas the other two countries have large palm plantations through good management and the palm oil producing industry is also supported by the government. As a consequence, Office of Agricultural Economics set up the Strategies of Thailand's Oil Palm and Palm Oil under the framework of AEC as follows (Anonymous, 2014).

**Strategy for the development of the oil palm production:**

The strategy for the development of Thailand's oil palm production aims to create efficient foundation for the production of Thailand's oil palm such as low production cost, high yield per rai, quality output and consistent output, etc. Experts are brought in to assist in the research

and development of palm species to yield output as much as production from large producers as well as dissemination and support to growers for concrete production.

**Strategy for the expansion of appropriate areas for cultivation:**

Although, Thailand is ranked third in the world as producer of oil palm and palm oil with sufficient domestic consumption, the expansion of cultivation in suitable land is still a major strategy that relevant agencies must drive to concrete ends in order to meet the consumption and use as alternative energy in the future including the possible expansion to neighboring countries with potential and appropriate areas.

**Strategy of integration to increase strength:**

The strategy promotes the integration of palm growers, palm oil extracting factories and continuous industries to increase bargaining power for growers who are mostly smallholders as well as price stability, production costs, stability and quality of raw material, increasing competitiveness.

**Strategy for creation of value added:**

Oil palm and palm oil are products with numerous benefits. They can be used in many continuous industries such as food, processed food, alternative energy and oleochemical. Therefore, the relevant agencies including the public, the private sectors and agencies supervising the oil palm policy, must continuously and concretely promote and drive the development.

**Strategy on management:**

This is the most necessary strategy in the systematic development of oil palm and palm oil, similarly to the Malaysian Palm Oil Board (MPOB). Despite many agencies or committees including the National Palm Oil Policy Committee, the operation has not progressed very well. It is therefore, crucial that there must be a national committee to manage oil palm and palm oil from grower's production to the final output to form unity in the development of Thailand's oil palm to meet the sufficient requirement of the country whether food or energy. Finally, it is also a source of income into Thailand.

**Knowledge crucial to the oil palm industry within the context of Thailand and ASEAN Economic Community:**

The synthesis of the research in combination with the study of the situations of oil palm from the past to the present can be summarized into problems and obstacles and knowledge crucial to the development of oil palm industry within the context of Thailand and ASEAN Economic Community. Knowledge is divided into three groups of stakeholders with major role in the entire oil palm industry namely growers and groups of growers,

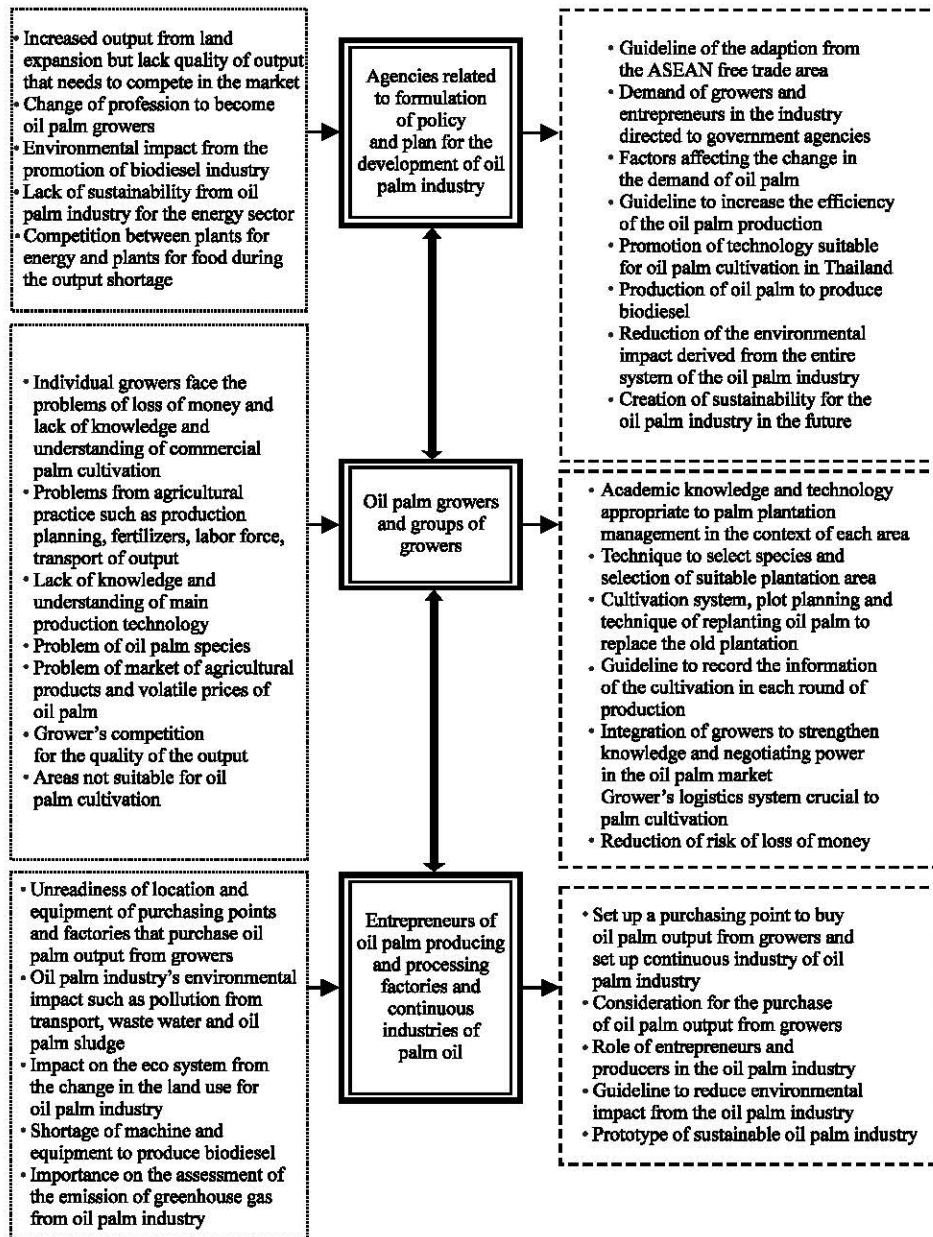


Fig. 2: Chart summarizing important information for the oil palm industry as synthesized by the research, black dashed lines mean knowledge that should be developed in the form of a handbook/Red dotted lines mean problems that should be used as a guideline to develop the handbook

entrepreneurs of oil palm processing and refining factories and continuous industries of oil palm and decision-making and planning agencies for the development of oil palm. It is accompanied by relevant documents. The findings reveal that the oil palm industry consists of oil palm growers who constitute the upstream oil palm industry. Oil palm output will be transported to the market where it is sent to palm oil extracting and refining factories or the intermediate oil palm industry. Afterwards, the palm oil which is gone through the

extraction and refining will enter the industry that uses palm oil as component or the downstream oil palm industry such as biodiesel producing factories, vegetable oil producing factories or food industry. The products will then be sent to consumers. There are many points in the information derived from the study that are useful in strengthening the oil palm industry. The study findings can also be additionally summarized that the stakeholders in the entire industry are inter-related. Any activities will have

impact on other compositions of the entire industry despite the different role and duty of each group as illustrated in Fig. 2.

### **CONCLUSION**

According to the selection of all the processes, the total of 53 topics of research works were compiled. The researcher divided the works according to economic, social, environmental, technology issues and other issues related to the integration of the knowledge of oil palm industry as follows: 14, 4, 7, 26 and 2 research topics related to the oil palm and palm oil industries in terms of the economic social, environmental technology and other issues both domestically and abroad, respectively. The researcher summarized and synthesized the main knowledge and problems related to the entire oil palm system by focusing on the creation of the knowledge to strengthen the entire system of the oil palm industry.

### **RECOMMENDATIONS**

According to the concept and related research, it can be explained that oil palm growers face high production costs of oil palm due to the increased prices of production factors. The irregular oil palm output, the inefficient management of oil palm plantations such as oil palm fronds and soil sample in the oil palm plots for nutrient analysis in a lab allow us to know the real need of nutrient and correct oil palm tree maintenance. These factors encourage the recognition of technology to manage grower's oil palm plantations, taking into account the age of the growers. These are supported by the information on the income from oil palm cultivation and grower's attitude in accepting the technology of the management of oil palm plantation. There are research works that support the use of organic fertilizers in combination with chemical fertilizers and groundcover to make the soil in the oil palm plantations richer. However, it takes a long time, approximately 3-5 years for the harvest. Most growers pay a lumpsum for the harvest because they do not have vehicle and labor themselves. The growers also need to consider the prices and convenience in transporting the oil palm output to the purchasing points or oil palm extracting factories. Oil palm growers still want to invest with government agencies to group themselves and set up oil palm cooperatives. But, they do not have knowledge and understanding of legal matters and business operation in the form of cooperatives. Moreover, they still need relevant agencies to support them with

land reform such as support the oil palm cultivation in unused land with access to water in order to distribute income and reduce encroachment of rich land in terms of eco system for oil palm cultivator. An independent organization may be set up to inspect ownership of land for oil palm cultivation as well as support from the government agencies to jointly formulate the policy of the oil palm production with quality and in demand in the world market. It can be summarized that there should be promotion to increase quality, reduce production costs and create value added to oil palm growers who constitute the upstream industry of the oil palm industry.

For the intermediate oil palm industry such as oil palm extracting and refining factories, most wastes are wastewater from production. Therefore, wastewater should be treated before releasing it into the environment or bringing the wastewater from oil palm processing into the production of biogas to reduce the emission of greenhouse gas from the wastewater from oil palm processing at the highest 50% and the biogas can be used as alternative fuel such as liquidified petroleum gas or fuel in factories. Moreover, the purchasing points or factories which purchase raw palm fruit from oil palm growers should use the criteria to select output based on fairness, reliability to reduce the loss of oil palm output such as setting up of criteria to buy only ripe oil palms or developing the method to efficiently select oil palm output to replace visual selection of oil palm output.

The downstream oil palm industry such as food industry and consumers of products with oil palm components is yet one more mechanism to drive the sustainability of the industry, especially, to encourage the entire oil palm industry to have a mechanism to demonstrate responsibility towards the society and the environment. The mechanism will also encourage the industry to have environmental standard certification such as carbon label, carbon footprint, water footprint which will stimulate the palm industry to focus on the reduction of environmental impact derived from the oil palm industry and is yet another channel to publicize that Thailand's oil palm industry pays attention to measures that reduce environmental impact.

### **REFERENCES**

- Anonymous, 2013a. Industrial cooperation with neighboring countries (strategic development for industrial cooperation under the project framework]. Center for International Trade Development, University of the Thai Chamber of Commerce, Bangkok, Thailand.

- Anonymous, 2013b. Oil Palm to Palm oil. Kasikorn Research Center Co., Ltd. Phaya Thai, Bangkok.
- Anonymous, 2014. Thai oil Palm production under AEC framework: ASEAN economic community. Center for International Trade Development, University of the Thai Chamber of Commerce, Bangkok, Thailand.
- Anonymous, 2015. Coal is stable energy base of ASEAN. Electricity Generating Authority of Thailand, Thailand, Asia.
- Aujirapongpan, S. and D. Mettarikanon, 2011. Development of exchange patterns and knowledge building on the innovative capabilities of small and medium enterprises: Palm oil extraction industry in upper Southern province. *J. Inf. Sci.*, 29: 1-12.
- Cramb, R. and G.N. Curry, 2012. Oil Palm and rural livelihoods in the Asia-Pacific region: An overview. *Asia Pac. Viewpoint*, 53: 223-239.
- Juntarumporn, P., 2012. Compare Growth between 6 Varieties of Oil Palm in to Desert Shrimp Pond at the Ages of Third and the Fourth Year. Maejo University, Nong Han, Chiang Mai, Thailand.
- Newton, P., A. Agrawal and L. Wollenberg, 2013. Interventions for achieving sustainability in tropical forest and agricultural landscapes. Master Thesis, International Food Policy Research Institute, Washington, DC., USA.
- Nissapa, A., 2001. Behavioral change to management in oil palm plantation project in peatland area of Bacho Narathiwat. *Songkhla Nakarin J.*, 7: 59-74.