Socio technical analysis of palm oil plantation in North Sumatera Indonesia: making sustainable supply

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Abstract. This paper has an aim to present a socio-technical analysis of palm oil plantation in North Sumatera Indonesia. This analysis is beneficial to support stakeholders in the Indonesian palm oil industry in designing strategic plans for making sustainable supply of palm oil. North Sumatera province has large areas of palm oil plantation and acts as one of important crude palm oil producer for Indonesia. Palm oil industry contributes to the economic and to the life of citizen in this province. To sustain supplies from palm oil plantations, social and technical aspects are necessary to maintain. Social aspects such as the behaviour of palm oil smallholders in cultivating their plantations and technical aspects such as availability of technology to support palm oil cultivation influence the supplies from plantations. Socio-Technical Framework and SWOT (Strength, Weakness, Opportunity, and Threat) were used to analyze the existing condition of palm oil plantation in North Sumatera Indonesia. To get supporting information, interviews with farmers, suppliers, palm oil researchers were conducted. The result indicates that there are several weaknesses and threats reducing the chance to sustain the supplies of palm oil.

1. Introduction
Palm oil is one commodity contributed significantly to the Indonesian economy. Around 13% of the Indonesian exports are given by the palm oil industry. Furthermore, this industry brings excellent social impact by absorbing manpower significantly. Approximately 5.5 million workers absorbed by this industry. For this reason, the Indonesian government has a desire to sustain palm oil supplies. Definition of sustainable supplies here is the Indonesian Palm Oil Industry can continue to produce palm oil products by considering the impacts on the environment, society, and economy. In the agricultural industry, supply depends on the sourcing stage which is plantation or farming areas. Hence, to achieve sustainable supplies from the palm oil industry, the supply of palm fruit bunches from palm oil plantations need to be sustained.

The supply from palm oil plantations depends on the productivity of that plantation. This productivity is influenced by several factors such as the way of cultivation, the type of palm oil trees planted and the age of palm oil tree [1]. Palm oil tree has different productivities within its life cycle. For example, for the age 0-3 years, palm oil tree does not produce palm fruit bunches. Palm oil tree starts to produce after the age of three and achieves maximum productivity at the age 10-20 years. However, this productivity still influenced by the way of cultivation applied to the plantation. For example, fertilizer treatment and the way of harvesting. This discussion indicates that social and technical aspects influence the productivity of palm oil tree which in turn affecting the supply.

To achieve sustainable supplies from palm oil plantations social and technical aspects need to maintain. Focus on technical aspects only will reduce the ability of plantations to supply palm fruit bunches. However, study of literature indicates that majority of papers related to palm oil plantation focused on one aspect only such as Rhebergen et al. [2] that focused to investigate impact of water and nutrient management on yield from palm oil plantations and Schoneveld et al. [3] that focused to investigate agricultural practices by palm oil smallholders in Indonesia. This paper analyses the social
and technical aspects of palm oil plantation in North Sumatera Indonesia. This paper consists of four sections. The second section presents the research method used for conducting socio-technical analysis of palm oil plantations. A combination of socio-technical framework and SWOT (strength, weakness, opportunity, and threat) was used as a research method. The third section displays the socio-technical analysis of palm oil plantations in North Sumatera Indonesia. Finally, in the fourth section, conclusion, limitation of research and possibilities for future research are discussed.

2. Research Method
This research has an objective to evaluate the existing condition of social and technical aspects in palm oil plantations in North Sumatera Indonesia. This analysis is required by stakeholders in the Indonesian palm oil industry to design a strategic plan for sustaining supplies of palm oil. To achieve this objective, a combination of socio-technical framework and SWOT (strength, weakness, opportunity, and threat) was used as research method. Figure 1 displays this combination.

This research uses socio-technical framework developed by Davis et al. [4]. This framework consists of internal and external factors. There are six factors to reflect social and technical aspects within the system including goals, people, infrastructure, technology, culture, and process. Then three external factors were used in framework to reflect the influence from outside of system including stakeholders, regulation and financial situation. The socio-technical framework is used to analyze the existing condition of social and technical aspects in palm oil plantation. The output from this analysis is the descriptions of social and technical aspects. These descriptions are then categorized into positive and negative situation. The positive conditions from social and technical aspects are classified as the strength of the system while the negative conditions from social and technical aspects are rated as the weakness of the system. For external factors, the positive conditions are grouped as the opportunity for the system and the negative conditions are assigned as the threat for the system.

To get the supporting data, several data collection techniques were performed including direct observation, literature review, and interviews. Palm oil smallholders, palm fruit bunch suppliers, and
palm oil researchers were interviewed and observed to identify the agricultural practices performed while cultivating palm oil plantations. A literature review was performed to identify existing regulations and programs related to palm oil plantations.

3. Result and Discussion
North Sumatera Province has more than 800,000 Ha palm oil plantations areas with around 50% of these areas are managed by palm oil smallholders. These areas produce more than 10 million ton of palm fresh fruit bunch per year [5]. To sustain these supplies, plantation areas are not only critical factors, other factors such as cultivation techniques, the behaviour of palm oil smallholders in cultivating their plantations, availability of fertilizer influence the ability to sustain the supply. This section presents the analysis of social and technical aspects for palm oil plantations in North Sumatera Indonesia. Figure 2 displays the socio-technical analysis of palm oil plantations in North Sumatera.

Figure 2. Socio-technical analysis of palm oil plantations in North Sumatera Province.
3.1. Analysis of external factors

Three external factors influenced the supply of palm oil have been analyzed including regulations, situation, and stakeholders.

- Regulation
  Indonesia has developed Indonesia Sustainable Palm Oil (ISPO) to promote sustainability in the palm oil industry. ISPO is a certification scheme for palm oil plantations and palm oil processors who follow a set of regulations while running their plantations. This regulation focus to evaluate several factors including the legality of plantations, agricultural practices, monitoring the environment, responsibility for the employee, responsibility for community and sustainability practices. Until now, there are more than 700 palm oil plantations companies have succeeded to get ISPO certificate. However, although almost 45% palm oil plantations in Indonesia are managed by smallholders, there is a low number of palm oil plantations owned by smallholders have participated in ISPO certification. This is due to many plantations area owned by smallholder do not have clear legality. Furthermore, some of the smallholders are difficult to implement good agricultural practices due to limited funding.

- Financial Situation
  In the last ten years, Indonesia has a good economic condition with the growth of around 5% per year. This situation is supported by the policy of the Indonesian Government to allocate funds to support replanting programs for palm oil smallholders. This program is to support palm oil smallholders to conduct replanting for their plantations. However, the volatile of palm oil price has put the smallholders and companies under the risk. This is because the cost to cultivate the plantations was higher than the palm oil sales. In addition, some regions such as Europe has put high taxes for crude palm oil products from Indonesia. This can bring significant impacts to crude palm oil processors in Indonesia which in turn affecting the price of palm oil at plantation level.

- Stakeholders
  Stakeholders play an important role to make palm oil supplies more sustainable. Several stakeholders have released programs to achieve sustainable supplies of palm oil. The first stakeholder is the Indonesia Government. Several programs such as ISPO (Indonesia Sustainable Palm Oil) certification, Replanting Aid for palm oil smallholders and providing fertilizer subsidy are performed by Indonesia Government. To implement these programs, the Indonesia Government formed an agency to manage funds for palm oil plantations. The second stakeholder is banking that provides loan for palm oil smallholders to financial conduct replanting. Some of the smallholders have limited funds to conduct replanting due to the volatile of palm oil price. The third stakeholder is crude palm oil processors. Several crude palm oil processors in North Sumatera have been identified to have programs to support the smallholders to do replanting. These processors provide funds, palm oil seeds and fertilizer for palm oil smallholders who supply fresh palm oil fruit to their factories.

3.2. Analysis of internal factors

An analysis of social and technical factors in palm oil plantations in North Sumatera is presented in this section. This analysis was produced from interviews with palm oil smallholders, palm oil suppliers and palm oil researchers in North Sumatera Indonesia.

- Goals
  This indicator reflects the goals of the owner of palm oil plantations. In North Sumatera, there are three types of plantations which are managed by different owners. First is palm oil plantations owned by smallholders. Second is palm oil plantations owned by state-owned companies. Third is palm oil plantations owned by private companies. From these plantations, state-owned companies and private companies have the vision to sustain the supply from their plantation. This is proven by many plantations owned by state-owned companies and private companies have received ISPO (Indonesia Sustainable
Palm Oil) certificate. On the contrary, the majority of palm oil smallholders do not think about sustainable supply. The main goal of smallholders is to generate income from their plantations.

- **People**
This indicator reflects the characteristics of people who manage the palm oil plantations. For plantations owned by state-owned companies and private companies, the employee who manage the plantations usually has good and related education with palm oil plantations. Furthermore, these companies always improve the skill and education of their employee by conducting annual training. On the contrary, the majority of palm oil smallholders are ordinary people. Their education is not always related to palm oil plantations. As a result, the majority of palm oil smallholders need support to cultivate their plantations.

- **Culture**
This indicator reflects the behavior of people who manage the palm oil plantations. For plantations owned by state-owned companies and private companies, the employee who manages the plantations has good cultures such as open for new and good agricultural practices. However, palm oil smallholders demonstrate the behavior that is easily influenced by the palm oil price. For example, although, the fertilizer treatment for palm oil plantations has a fixed schedule, the decision of some smallholders to apply fertilizer is influenced by palm oil price and fertilizer price. If the fertilizer price is increasing and the palm oil price is reducing, the smallholders tend to not apply the fertilizer. Another important culture is the ability of smallholders to form a group as a place for sharing information. The group of smallholders is one requirement to get support from related stakeholders such as government and crude palm oil processor. There are more than 25,000 palm oil smallholder groups in North Sumatera. This indicates the smallholders in North Sumatera have realized the importance of smallholder group to support their activities.

- **Infrastructure**
Seven issues have been identified as the important infrastructure required to support sustainable supply including palm oil plantation areas, palm oil seed producer, fertilizer producer, palm oil research center, crude palm oil processor, a government agency to support palm oil industry and road to access plantation areas. For palm oil plantation areas, in North Sumatera, it has been identified several districts that have imbalance composition of plantation areas. For example, in Labuhan Batu district, the total productive area is around 32,000 Ha while the total immature area is only around 2,000 Ha. This indicates, in the future, the supply is likely to reduce due to many productive areas entering not productive phase while the immature areas to replace the productive areas that enter not productive phase is quite low.

There is limited high-quality seed available for replanting due to the low number of registered palm oil producers in North Sumatera. To be registered as an official palm oil producer, several evaluations by the institution under the Indonesian Ministry of Agriculture must be taken. As a result, to cover the demand for high-quality seed in this province, the seed must be exported from other provinces in Indonesia.

There are several fertilizer producers in North Sumatera. However, the total fertilizer production is less than fertilizer demand in North Sumatera. As a result, some of this demand is fulfilled by exporting fertilizer from other provinces such as Nanggroe Aceh Darussalam Province and East Java Province. Furthermore, fertilizer suppliers who distribute fertilizer into plantations are not available in every village where plantations are located. As a result, smallholders in these villages must buy fertilizer from another village which increases fertilizer cost.

Crude palm oil processors play a role to transform fresh palm fruit from plantations into crude palm oil and kernel palm oil. In North Sumatera, there are more than 80 crude palm oil processors that are located in several districts such as Labuhan Batu, Langkat, Serdang Bedagai, and Deli Serdang near to plantation areas. This condition makes palm oil smallholders easier in selling their fresh palm fruit with low distribution cost.
Other issues in infrastructure related to the availability of the research center. This agency plays a role to supply technology and innovation for plantations. These technology and innovations influence the productivity of plantations. There is one palm oil research center in North Sumatera Province which located in Medan. This research center has provided training for good agricultural practices as well as technical support for evaluating the productivity of plantations. Plantation agency is expected to provide essential support for palm oil smallholders. North Sumatera Provincial Government has plantation agency which has the roles to monitor palm oil production and to support palm oil smallholders with training for good agricultural practices, high-quality palm oil seed, and other technical supports. Last issue in infrastructure related to the road to access the plantations. Availability of road is necessary for distributing fresh palm fruit to crude palm oil processors. Majority of plantations in North Sumatera are connected by the road. Some state-owned and private companies have developed new roads to access their plantations.

• Technology
This indicator reflects the mastership of technology for cultivating palm oil plantations. Plantations under state-owned and private companies have applied good agricultural practices while plantations under smallholders might not apply good agricultural practices comprehensively due to limited funds and knowledge. As a result plantations under smallholders tend to have lower productivity comparing with plantations under state-owned and private companies. Another issue in technology related to replanting technique. Not all palm oil smallholders have experience and knowledge in conducting replanting. This is due to the long life cycle of palm oil plantations which is around 20-25 years. Many plantations under smallholders are still within the productive phase and are not yet entering the non productive phase.

• Process
This indicator reflects the process for distributing fresh palm fruit from plantations into crude palm oil processor. For plantations under state-owned and private companies, fresh palm fruit is transported directly from plantations into crude palm oil processors. For plantations under smallholders, fresh palm fruit is transported through several channels including village suppliers and districts suppliers. At the village level, fresh palm fruits are bought and collected by village suppliers. Then, district supplier collects fresh palm fruits from several village suppliers and sends those fresh palm fruits directly to crude palm oil processors. This situation influences the price of fresh palm fruit which in turn affecting the income of smallholders from palm oil plantations.

3.3. SWOT analysis of palm oil plantations in North Sumatera Province.

SWOT analysis is performed to identify the strength, weaknesses, threat, and opportunity of palm oil plantations in North Sumatera. This analysis used the output from the socio-technical framework as the input for analysis (see Figure 1). Table 1 summarizes the strength, weakness, opportunity, and threat for Palm Oil Plantations in North Sumatera.

| Opportunity | Strength |
|-------------|----------|
| • Indonesia has developed Indonesia Sustainable Palm Oil (ISPO) to promote sustainability in the palm oil industry. | • Indonesian Government as regulator and important stakeholder in natural rubber plantation has the vision to sustain palm oil supply. This vision is implemented through the ISPO certification and replanting program. |
| • Related stakeholders are active to give support for palm oil smallholders. For example, the Indonesian Government gives funding and training to support replanting performed by palm oil smallholders. | • Crude palm oil processors have the vision to sustain palm oil supply, which is implemented by giving support for palm oil smallholders to conduct replanting. |
support replanting programs for palm oil smallholders.

- Indonesian Banking provides loan for palm oil smallholders to support replanting their plantation.

- There is one palm oil research center located in Medan district. This research center contributes to developing innovations to cultivate plantation.

- There are more than 25,000 palm oil smallholder groups. These groups can be the place for spreading information within palm oil smallholders.

| Threat                                      | Weakness                                                                 |
|---------------------------------------------|--------------------------------------------------------------------------|
| • Palm oil price is volatile and tends to decline in the last years. | • All stakeholders focused on their own goal and program. The collaboration of program between stakeholders seems to be rare. As a result, many programs are overlapping. |
| • Some regions such as Europe has put high taxes for crude palm oil products from Indonesia. This can bring significant impacts to crude palm oil processors in Indonesia which in turn affecting the price of palm oil at plantation level | • Palm oil smallholders are dominated by ordinary people with unrelated educational background. This situation delivers the fact that these key players need support to manage their plantations. |
|                                             | • The behavior of palm oil smallholders in giving fertilizer is influenced by several factors such as fertilizer prices and latex price. |
|                                             | • Imbalance composition has been found in several districts. For example, in one district, total of the not productive area is higher than the productive area. Furthermore, in many districts immature area is found to be quite low compared with the productive area. |
|                                             | • Currently, high-quality palm oil seed is available at certain time due to limited palm oil seed producer. |
|                                             | • Not all sub-districts and villages with palm oil plantation areas are covered by fertilizer supplier. |
|                                             | • Not all palm oil smallholders overcome the good agricultural practices for palm oil plantation. |
|                                             | • Not all palm oil smallholders have experience and knowledge about replanting technique. |
|                                             | • For plantations under smallholders, there is long supply chain for distributing fresh palm fruit from plantations into crude palm oil processors. |

4. Conclusion

Maintaining social and technical aspects are required to achieve sustainable supplies from palm oil plantations. This paper analyses the existing condition of social and technical aspects for palm oil plantations in North Sumatera Province. To do the analysis, this research demonstrates the use of the socio-technical framework and SWOT (strength, weakness, opportunity, and threat). The socio-technical analysis indicated various threats in making the sustainable supply. Those threats are volatile of palm oil price and the application of high tax from European Union for Indonesian palm oil products. However, the possibilities for sustainable supplies are increasing due to availability of Indonesia Sustainable Palm Oil (ISPO) regulation and supporting programs from related stakeholders.

The analysis also displayed the weaknesses in social and technical aspects. For social aspects, the weaknesses are identified for goal and culture indicators. Palm oil smallholders are detected to have the main goal to generate income rather than to sustain the supply. Furthermore, the majority of palm oil smallholders have the unrelated educational background to manage plantations. For technical aspects, the low number of palm oilseed producers and imbalance composition of plantations in several districts
are identified as the weaknesses. Related stakeholders have wider opportunities to use this analysis in formulating strategic and operational plans for sustaining palm oil supplies.

Acknowledgment

We would like to thank Universitas Sumatera Utara Research Centre for supporting this research with research grant number: 4167/UN5.1.R/PPM/2019.

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