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Socio-technical analysis of natural rubber plantation in North Sumatera: possibilities for sustaining supply

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Abstract. Natural rubber is an important commodity for countries in South East Asia region such as Indonesia, Thailand, and Malaysia. Economic in these countries are supported by exporting this commodity. Many citizens of these countries depend their life on income from a natural rubber plantation. Moreover, natural rubber is a key material to produce important products such as tire, health and sports equipment. For this reason, it is necessary to sustain the supply from natural rubber plantation. To sustain the supply, technical aspects such as cultivation techniques, replanting techniques, latex processing techniques and social aspects such as rubber smallholder behavior, supplier behavior need to maintain. This research conducts a socio-technical analysis of natural rubber plantation in North Sumatera. This research has an objective to investigate the ability of natural rubber plantation in North Sumatera to sustain the natural rubber supplies. A combination of socio-technical framework and SWOT (Strength, Weakness, Opportunity, and Threat) is used to analyze the existing condition of natural rubber plantation in North Sumatera. The result indicated that there were social, technical and external factors that reduce the ability to sustain the supply of natural rubber.

1. Introduction

Natural rubber plantation becomes a source of income for citizens in Indonesia, Thailand, and Malaysia. In these countries, more than 80 % of natural rubber plantations are managed by rubber smallholders. After through various processing such as crumb rubber processing, ribbed smoke sheet processing, high centrifuged processing, natural rubber can be used as raw material for several products such as tire, glove, health, and sports equipment [1]. Given the importance of natural rubber, it is necessary to sustain the supply from natural rubber plantation. To achieve this, developments in technical aspects such as infrastructure, technology, process and social aspects such as goals, culture, people are required. Development in one aspect only might not produce an optimum impact in sustaining supply. Socio-technical system thinking is one systemic approach that has been widely used to investigate an interaction between social and technical elements in a system. The ability of this approach to capture socio and technical elements presents significant opportunity to be used as a framework to examine North Sumatera natural rubber plantation. The social elements of natural rubber plantation such as rubber smallholders with their behavior and characteristics can be captured using this framework as well as the technical elements such as infrastructure condition.

One of the socio-technical frameworks is proposed by Davis et al. [2]. This framework is described as a hexagon with three external factors. Interaction between social and technical elements is well presented in hexagon. Six main elements of the hexagon are goal, people, culture, infrastructure, technology, and process/method. Six main elements are influenced by three external factors including stakeholders, financial circumstances and regulation. This paper has an objective to analyze the



existing condition of natural rubber plantations in North Sumatra. The combination of socio-technical framework and SWOT (Strength, Weakness, Opportunity, and Threat) is used to support the analysis. This analysis is used to support the related stakeholders in North Sumatra natural rubber industry for formulating strategic plans to sustain supply from natural rubber plantation. This paper consists of four sections. The second section displays the combination of socio-technical framework and SWOT that used as a research method. In the third section, the analysis of natural rubber plantation in North Sumatra is presented. Finally, in section four, conclusion and future research are explored.

2. Research methods

The combination of socio-technical framework and SWOT (Strength, Weakness, Opportunity, and Threat) were used as the research method. The socio-technical framework proposed by Davis et al. [2] was used as part of the method. To represent social and technical aspects within the system this framework introduced hexagon with six principal elements including goals, people, culture, technology, infrastructure, and process. These six elements are influenced by three external factors including regulation, financial situation, and stakeholders. By using this framework, the current condition social and technical elements in natural rubber plantation, as well as external factors that influence the system, can be observed and evaluated.

Then, the result from socio-technical framework is used as an input for SWOT analysis. In this analysis, the existing condition of social and technical aspects, as well as the condition of external factors, are categorized into positive and negative condition. The positive condition from social and technical aspects are included as strength factors from the system while the positive conditions from external factors are grouped as opportunity factors for the system. On the contrary, the negative condition from social and technical aspects are categorized as weakness factors from the system while the negative conditions from external factors are included as threat factors for the system. Figure 1 shows the combination of socio-technical framework and SWOT.

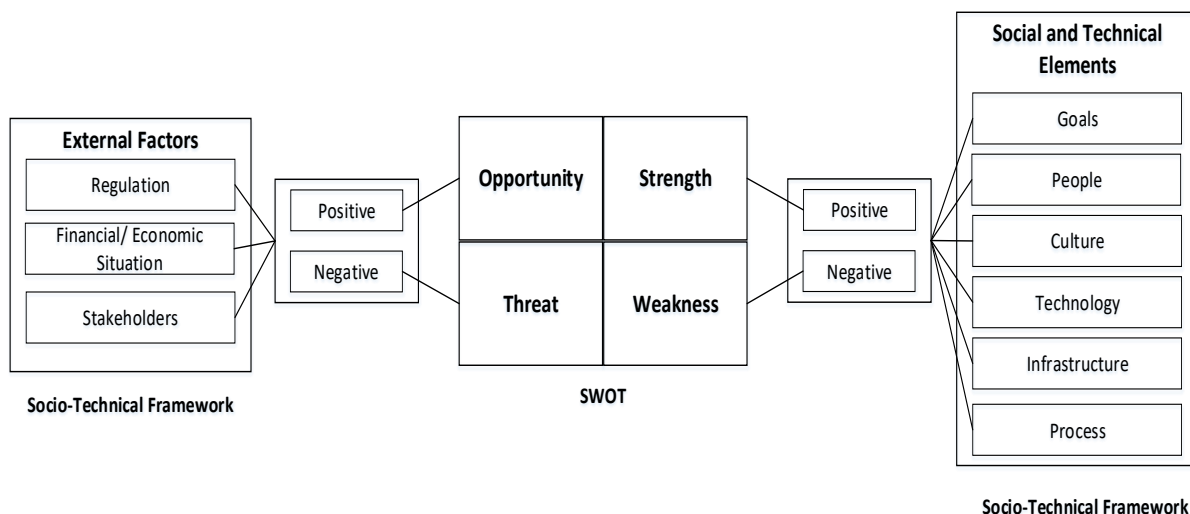


Figure 1. The combination of socio-technical framework and SWOT.

This research used several data collection techniques such as literature review, direct observation, and interviews to get supporting data. A literature review was used to get information related to the standard of cultivation techniques for natural rubber plantation. Interview and observation were used to gain information about current cultivation techniques applied by rubber smallholders in North Sumatra. Several participants such as rubber smallholders, natural rubber suppliers, representative from natural rubber processor association and academics in North Sumatra have been interviewed.

3. Result and discussion

North Sumatera Province is one important province in Indonesia with big natural rubber plantation areas. This province produces around 311,000 ton natural rubber that contributes to Indonesian Gross Domestic Products. Currently, there are more than 286,000 hectares productive areas with immature areas around 47,000 hectares in this province [3]. However, to sustain natural rubber supply, rubber plantation area is not only critical factors. Other factors such as cultivation techniques, rubber smallholder behavior influence the ability to sustain natural rubber supply. Hence, can the supply from natural rubber plantation in North Sumatera be sustained to become the main questions for related stakeholders in North Sumatera Natural Rubber Industry? To answer this question, the evaluation of the existing condition of natural rubber plantation in North Sumatera is required. Figure 3 displays the analysis of existing natural rubber plantation in North Sumatera.

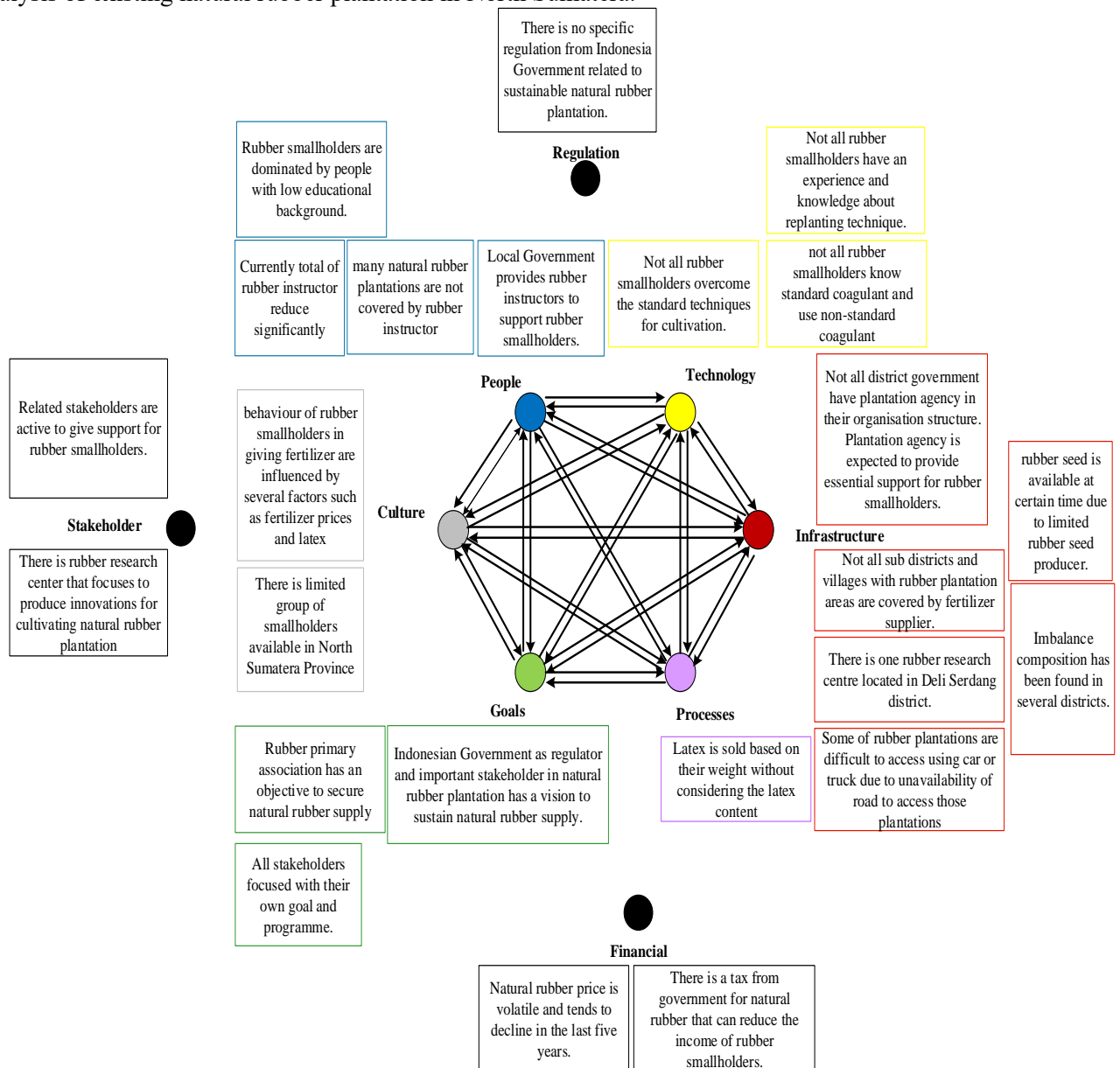


Figure 2. Socio-technical analysis of natural rubber plantation in North Sumatera Province.

3.1. Analysis of external factors

An interview with stakeholders in North Sumatera natural rubber industry has indicated three external factors that can push the sustainable supply. The first factor is the relevant stakeholders. Three related stakeholders have been identified to have an ability to push sustainable supply from natural rubber plantation. Local government is the first stakeholder that has the authority to give license in opening rubber plantation. Furthermore, this stakeholder has funding that can be used to generate support for rubber smallholders. Different supports such as training for cultivation and replanting and equipment for coagulating latex have been given for rubber smallholder. The second stakeholder is rubber primary processor associations. This stakeholder receives natural rubber supply from plantations. This stakeholder has the authority to push sustainability practices to suppliers. For example, in term of quality, this stakeholder can push plantations to improve the quality of raw material by rejecting raw materials that have a lower standard. This stakeholder also provides supports for rubber replanting process such as rubber seed, fertilizer, and funding. The third stakeholder is a rubber research center. As research center, this stakeholder supplies innovations to rubber smallholders for managing their plantations such as tapping method, replanting method and latex processing method. This stakeholder could resolve problems that emerge in rubber plantations such as plant disease, low productivity, and low quality.

The second factor is the financial situation. Latex price is one financial factor that can push rubber smallholders to be more sustainable. For example, the reduction of latex price in North Sumatera has affected cultivation technique implementing by rubber smallholders because this situation has reduced the income of smallholders and suppliers. This reduction has pushed rubber smallholder to reduce cultivation cost including fertilizer cost, herbicide cost, and labor cost although these actions might decrease the productivity of plantation. Another financial situation is a tax for latex. This tax is applied by local government to the primary processor for each kg of exported natural rubber. This tax has pushed the primary processor to charge suppliers which in turn affecting latex price at district and village level. These situations are potential to disturb natural rubber supply.

The third factor is the regulation. This factor is a set of rules that produce by government and legislative. This regulation controls activities within natural rubber supply plantation. For example, regulation of land conservation has limited the use of land as rubber plantation. Furthermore, regulation related to tax for natural rubber product has influenced the latex price at district and village level. However, there is no regulation related to sustainable natural rubber supplies in North Sumatera.

3.2. Analysis of social and technical aspects of natural rubber plantation in north sumatera

This section presents an analysis of social and technical aspects for natural rubber plantation in North Sumatera. This analysis was produced based on information gained from the interviews with several stakeholders in North Sumatera Natural Rubber Industry including rubber smallholders, rubber researchers, rubber primary processor association, local government, and academics.

- **Goal**

This element refers to a set of goals from key players in natural rubber plantation. North Sumatera natural rubber plantations are dominated by rubber smallholders who own plantations with a square area less than five hectares. The main goal of rubber smallholder is to provide income for their life. Majority of rubber smallholders do not have other sources of income and depend on their life on income from rubber plantations. This situation shows the vulnerability of smallholders to the price of latex. Reduction of latex price might directly affect the income of smallholder.

Indonesian Government as regulator and important stakeholder in natural rubber plantation has the vision to sustain natural rubber supply. This vision is implemented through the revitalization program for rubber plantations. This program has a goal to return not productive plantation into productive by providing replanting funding for rubber smallholders. This program is strengthened by the Provincial government who has similar mission with the central government in natural rubber supply. The provincial government has allocated program and funding for rubber smallholders. The examples of program are the training to improve smallholders' skill, replanting aid and equipment for latex

processing. However, this mission is not followed by district governments. Some of the district governments do not have program and funding allocation to support natural rubber plantation.

Other stakeholders such as rubber primary association and rubber research center also play an important role in sustaining natural rubber supply. Rubber primary association has an objective to secure natural rubber supply since their production could be stopped if there is no supply from the plantation. To support this goal, rubber primary association support smallholders' replanting activities by providing rubber seed. Furthermore, rubber research center has an objective to create technology and innovation for rubber plantation cultivation. These technologies and innovations are used by rubber smallholders in improving productivity and solving the problem within plantations. However, many rubber smallholders are unable to access these technologies and innovations. As a result, the mastership of technology such as replanting technique, latex processing technique, tapping techniques is limited in smallholders.

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. For example, replanting support for smallholders from the Provincial government and rubber primary association are allocated in the same district with similar form of support. The collaboration of stakeholders could improve the program by providing a different form of supports and reach more targets.

- People

In natural rubber plantation in North Sumatera, the majority of key players are ordinary people such as rubber smallholders and suppliers. Characteristic and profile of these key players have influenced the decision-making process. For example, the education background of rubber smallholders might influence their way in managing plantations. The observation in North Sumatera Province indicated that rubber smallholders are dominated by people with low educational background. This situation delivers the fact that these smallholders need support to manage their activities. Rubber instructor is a government officer that offer the support to key players in natural rubber plantations. Rubber instructor has a function to support rubber smallholders in term of knowledge and skills. In other words, the rubber instructor is a bridge for transferring innovations and technology to rubber smallholders. For example, rubber instructors have a responsibility to address the needs of smallholders in term of cultivation methods, solving plant disease, and any information related to managing rubber plantations. However, currently total of rubber instructor reduce significantly. As a result, many natural rubber plantations are not covered by rubber instructor. Rubber smallholders located in these areas are unable to get support from rubber instructor.

- Culture

The main issue in culture is the behavior of key players. These behaviors influence natural rubber supply. For example behavior of rubber smallholders in giving fertilizer is influenced by several factors such as fertilizer prices and latex price. As a result, while latex price decrease, the productivity of plantation could be reduced due to less fertilizer applied by rubber smallholder. Another important issue related to culture is the ability of smallholder to form a small group. This small group has a structure of the organization, set of rules and work schedule. This small group is functioned as a place for sharing information and problems in managing plantation. The small group facilitates the transfer of technology within members of group. Furthermore, to get aid and support from government and related stakeholders, rubber smallholders are required to form small group. Rubber smallholders who joined in small group usually have better performance in term of cultivation, productivity, and networking. However, not many rubber smallholders group are found in North Sumatera Province. Comparing to total of rubber smallholders in this province, total of small groups are not significant. This condition increases difficulties in supplying aids to support the rubber smallholders.

- Infrastructure

Infrastructure is one important element in supporting natural rubber production. There are several issues in infrastructure that has been found in North Sumatera Natural Rubber plantation. First is the composition of the immature, productive and not productive area. This composition is necessary for determining the capacity of supply for current and future. In North Sumatera, 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. As a result, reduction of supply might occur at certain time in the future.

Second is related to the availability of rubber seed. Currently, rubber seed is available at certain time due to limited rubber seed producer. Rubber seed is one critical factor that influences the productivity of plantation [4]. Unfortunately, the total production of rubber seed in North Sumatera is lower than the demand for rubber seed. As a result, to fulfill the demand, rubber seed from outside of the region should be exported. Currently, less than 30 companies are registered as rubber seed producers in North Sumatera Province. The main reason for this situation is because to produce high-quality rubber seed, the good raw material of rubber seeds producing by the high quality of rubber tree are required. Not all plantations produce good raw materials for rubber seeds. In North Sumatera only a few places that produce good raw material for rubber seeds. Furthermore, specific techniques are needed in producing high-quality rubber seeds. To be qualified in producing rubber seeds, companies must be examined by government institution under Indonesia ministry of Agriculture. This institution has a function to verify and validate raw materials and methods in producing rubber seeds.

The third issue in infrastructure is related to the availability of fertilizer. Not all sub-districts and villages with rubber plantation areas are covered by fertilizer supplier. As the consequences, rubber smallholders in those villages should find fertilizer suppliers in other villages or districts. Many of them have to travel in the far distance to the capital of the district or other sub-districts to get fertilizer. As a result, many of them do not apply fertilizer to their plantations due to unavailability of fertilizer. Government has tried to solve this problem by supplying subsidized fertilizer through official distributors. Unfortunately, a total of subsidized fertilizer is limited, which make this type of fertilizer only available at certain times.

The fourth issue in infrastructure is the availability of rubber primary processor. This processor has a function to transform raw material from rubber plantations into work in process materials such as crumb rubber, rubber smoke sheet, and high concentrated latex. In North Sumatera, there are 45 primary processors located in several districts such as Deli Serdang District, Labuhan Batu District, South Tapanuli District, and Medan. However, the location of primary processors centralized in some districts only while rubber plantations scattered in more than 20 districts. This situation has pushed some raw materials to travel in long-distance from plantations to the primary processor. This contributes to increase the cost of transportation which in turn affecting rubber smallholders' income.

Other issues in infrastructure related to the availability of rubber research center, the government agency for plantation and road to access plantation. In North Sumatera, there is one rubber research center located in Deli Serdang district. This research center contributes to developing innovations to cultivate plantation. The local government agency is an institution under the district government that focuses on managing rubber plantation. Not all district government have plantation agency in their organizational structure. Plantation agency is considered a necessary infrastructure since the majority of plantations are owned by rubber smallholders who have low productivity, low technology adoption, low funding and are susceptible to price. Plantation agency is expected to provide essential support for rubber smallholders. Road to access plantation is the last issue in infrastructure that has been found to influence material flow from plantations to primary processors. Majority of plantations are located in villages. Some of the rubber plantations are difficult to access using car or truck due to unavailability of the road to access those plantations. Some of the plantations even can only be accessed via the river. This contributes to increase time in supplying raw material to primary processors.

- Technology

This section describes the mastership of technology required in cultivating natural rubber plantation. Based on interviews and observation, not all rubber smallholders overcome the standard techniques for cultivation. For example, how to give fertilizer treatment to plantations, how to tackle plant disease are standard cultivation techniques that have to possess by rubber smallholders. Furthermore, many rubber smallholders do not know the standard technique for tapping rubber trees. The application of incorrect tapping technique might ruin the skin of rubber tree, which in turn stopping latex production.

Another issue is related to replanting technique. Not all rubber smallholders have experience and knowledge about replanting technique. This is because many rubber plantations are a heritage from the previous generation. Rubber replanting is likely to fail due to the application of incorrect replanting technique. For example, if land for replanting is not fully cleared from residual of old rubber tree particularly roots of old rubber, this can increase the probabilities of fungus to attack the new rubber tree. Another issue related to replanting is a technique to produce high-quality rubber seeds. Not many rubber smallholders have the ability to produce high-quality rubber seeds. As a result, most of the rubber smallholders have to buy the rubber seeds from rubber seed producers while total number of rubber seed producers is also limited. Furthermore, the last issue in technology-related to a technique for processing latex. Before, selling the latex, rubber smallholders need to coagulate latex with a standard coagulant. However, not all rubber smallholders know standard coagulant and use non-standard coagulant. This might decline the quality of latex which in turn reducing the latex prices. This is exacerbated by the behavior of rubber smallholders that tend to put unnecessary materials such as soil, small branch, in coagulated latex.

- Process

This element relates to the process for distributing natural rubber into rubber primary processor. In North Sumatera Province, natural rubber is distributed to rubber primary processor through village supplier and district supplier. At the village level, latex is sold based on their weight without considering the latex content. This occurred due to the unavailability of tools to check latex contents at village and district level. This situation has pushed rubber smallholders to increase the weight of their coagulated latex by adding unnecessary materials inside coagulated latex such as soil, branch, stone which in turn reducing the quality of coagulated latex. On the other hand, primary processors buy latex based on dry rubber content that is measured in the laboratory. This situation might put the suppliers (village supplier and district supplier) under a risk. Suppliers buy coagulated latex based on the weight from rubber smallholder and sell it to the primary processor based on dry rubber content.

3.3. SWOT analysis of natural rubber plantation in North Sumatera

SWOT analysis is performed to identify the strength, weaknesses, threat, and opportunity of natural rubber plantation 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 Natural Rubber Plantation in North Sumatera.

Table 1. SWOT analysis of natural rubber plantation in North Sumatera.

| Opportunity | Strength |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none"> • Related stakeholders are active to give support for rubber smallholders. For example, the local government gives funding and training to support replanting performed by rubber smallholders. • There is rubber research center that focuses to produce innovations for cultivating natural rubber plantation. | <ul style="list-style-type: none"> • Indonesian Government as regulator and important stakeholder in natural rubber plantation has the vision to sustain natural rubber supply. This vision is implemented through the revitalization program for rubber plantations. • Rubber primary association has an objective to secure the natural rubber supply. To support this goal, rubber primary association support smallholders' replanting activities by providing rubber seed. • Local Government provides rubber instructors to support rubber smallholders. • There is one rubber research center located in Deli Serdang district. This research center contributes to developing innovations to cultivate plantation. |

| Threat | Weakness |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none"> • Natural rubber price is volatile and tends to decline in the last five years. • There is a tax from the government for natural rubber that can reduce the income of rubber smallholders. • There is no specific regulation from Indonesia Government related to sustainable natural rubber plantation. | <ul style="list-style-type: none"> • 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. • Rubber smallholders are dominated by people with low educational background. This situation delivers the fact that these key players need support to manage their activities. • Currently total of rubber instructor is reduced significantly. As a result, many natural rubber plantations are not covered by rubber instructor. • Behavior of rubber smallholders in giving fertilizer is influenced by several factors such as fertilizer prices and latex price. As a result, while latex price decrease, rubber smallholders tend to reduce the application of fertilizer to their plantations. • There is a limited group of smallholders available in North Sumatera Province. Small group is necessary as a place for sharing information between rubber smallholders. • 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, rubber seed is available at certain time due to limited rubber seed producer. • Not all sub-districts and villages with rubber plantation areas are covered by fertilizer supplier. • Not all district government have plantation agency in their organization structure. Plantation agency is expected to provide essential support for rubber smallholders. • Majority of plantations are located in villages. Some of the rubber plantations are difficult to access using car or truck due to unavailability of the road to access those plantations. • Not all rubber smallholders overcome the standard techniques for cultivation. • Not all rubber smallholders have experience and knowledge about replanting technique. • Not all rubber smallholders know standard coagulant and use non-standard coagulant in processing latex. • Latex is sold based on their weight without considering the latex content. This occurred due to the unavailability of tools to check latex contents at village and district level. |

4. Conclusion

This paper demonstrates the combination of socio-technical framework and SWOT (strength, weakness, opportunity, and threat) for analyzing the existing condition of social and technical aspects in natural rubber plantation. The socio-technical analysis of rubber plantations in North Sumatera displayed several threats. For example, although, regulation is found as driver for sustainability [5], no regulation from Indonesia Government to push natural rubber plantations to be more sustainable. Furthermore, natural rubber prices are volatile with a tendency to decline in the last five years. This affects the profitability of natural rubber plantations. This situation might influence the decision of rubber smallholders to replant their plantations. To tackle this situation, related stakeholders such as the Indonesia Government, and rubber primary association have developed the programs to support smallholders' replanting. However, there is lack of coordination between stakeholders in applying for the programs.

The analysis showed that natural rubber plantations in North Sumatera have weaknesses in technical aspects including limited natural rubber seed producers, limited application of technologies in cultivating rubber plantations and imbalance composition of natural rubber plantation. For social aspects, some weaknesses have been identified particularly related to goal and culture of rubber smallholders. It has been found that the majority of rubber smallholders have the main goal to generate income and have not applied standard cultivation techniques completely. This analysis might be beneficial for related stakeholders in formulating masterplan for sustaining supply from natural rubber plantation.

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