Sustainability indicators for rubber plantations in Thailand: Environmental integrity dimension

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Abstract. The natural rubber industry has played a vital role in Thailand’s economic, environmental, and social contexts. Therefore, sustainable rubber production is a significant concern. At present, a wide variety of international tools has been developed to assess the agricultural sector’s sustainability performance. The Food and Agriculture Organization of the United Nations developed the Sustainability Assessment of Food and Agriculture systems (SAFA) in 2013. Environmental integrity is one of the dimensions of sustainability in SAFA. SAFA is applied to assess the impact of agriculture operations on the environment. This research aims to assess suitable environmental integrity indicators in compliance with SAFA for rubber plantations in Thailand. The system boundary is set to cover rubber plantations, harvesting of fresh latex, and rubber tree felling. This work conducted focus group discussions, using the SAFA, guidelines, indicators, and tools for rubber plantations, the review process by rubber plantation experts, representatives of rubber associations, SAFA researchers, and environmental scholars, and site visits to interview rubber farmers in the south, northeast, and north of Thailand. Environmental themes, including the atmosphere, water, land, biodiversity, and material and energy were included in assessing the environmental integrity of a rubber plantation. Animal welfare was not included.

1. Introduction
Thailand has an area of rubber plantations of 3.27 million ha and produces natural rubber of about 4.84 million tonnes yearly. This amount accounts for 33 percent of the total natural rubber in the world [1]. The rubber industry’s life cycle chain consists of rubber plantations, the production of intermediate rubber products, and the production of final products. The intermediate rubber products are ribbed smoked sheets (RSS), block rubber (Standard Thai Rubber, STR), and concentrated latex. The final
rubber products are gloves, condoms, belts, soles, vehicle tires, and industrial rubber parts [2] Therefore, the natural rubber industry has played a vital role in Thailand’s economic, environmental, and social contexts.

A rubber plantation starts from site preparation followed by rubber seedling cultivation, rubber cultivation, rubber tapping, and rubber tree felling, which takes approximately 25 years. Fresh latex and cup lumps are the products from a plantation. The fresh latex is the raw material of RSS and concentrated latex. The cup lump is used for producing block rubber. Hevea wood and branches are the products from the rubber tree felling and are used as the manufacturing of lumber AB [3]. The rubber plantation is the upstream phase of the life cycle of the rubber industry; therefore, the sustainable production of a rubber plantation is a significant concern.

A wide variety of international tools have been developed to assess the agricultural sector’s sustainability performance. The Food and Agriculture Organization of the United Nations developed the Sustainability Assessment of Food and Agriculture systems (SAFA) in 2013. SAFA is a universal framework for sustainability assessment. According to SAFA, the publication consists of SAFA guidelines, SAFA indicators, the SAFA tool, and SAFA smallholders App. [4] SAFA includes four sustainability dimensions: good governance, environmental integrity, economic resilience, and social well-being dimensions. Each dimension consists of themes, sub-themes, and indicators for assessing the sustainability of the target food or agriculture supply chains [5].

For assessing the sustainability of rubber plantations in Thailand by SAFA, the reviews of SAFA guidelines, SAFA indicators, the SAFA tool, analysis, and discussion among stakeholders have been conducted to obtain suitable themes, sub-themes, and indicators for each dimension. We aim to assess suitable indicators of environmental integrity in compliance with SAFA for rubber plantations in Thailand for this work.

2. Material and methods

2.1. System boundary and study area
The system boundary of the study is set to cover rubber seedling cultivation, rubber cultivation, rubber tapping, and rubber tree felling. Fresh latex, cup lump, and hevea wood and branches are the main products of rubber plantations. Southern Thailand has the largest rubber plantation area of about 2.17 million ha (60% of the total area of rubber plantations), followed by northeastern (0.84 million ha, 23%), central (0.39 million ha, 11%), and northern (0.22, million ha, 6%) Thailand, respectively [6]. The study areas for site visits, interviewing, and collecting data to develop and test the questionnaire of the environmental integrity dimensions were Songkhla province in southern Thailand, Bueng Kan province in northeastern Thailand, and Phitsanulok province in northern Thailand.

2.2 Methodology
According to SAFA, this work started by reviewing literature data and other sustainable assessment methods for agricultural products, especially rubber products. The goal, system boundary, and studied products were set. The secondary data of the study areas were collected. Then, the questionnaire for assessing the environmental integrity of a rubber plantation was developed by a working group concerned with the rubber plantation practices in all regions in Thailand. The questionnaire structures were mainly divided into five themes: atmosphere, water, land, biodiversity, and material and energy. Each theme is comprised of sub-themes and performance, practice-based, and target indicators compliant with the SAFA guidelines [5].The technical committees, which included rubber plantation experts, representatives of rubber associations, SAFA researchers, and environmental scholars were set. The technical committees reviewed each indicator’s questionnaire and rating score to assess the environmental integrity of rubber plantations in Thailand. The working groups visited the study area and collected data to build and test the questionnaire by interviewing 20 rubber farmers in Hat Yai, Songkhla, in November 2019, 23 rubber farmers in Seka, Bueng Kan in February 2020, and 30 rubber farmers in Wang Thong and Nakhon Thai, Phitsanulok in February 2020. In the final stage, the technical
committee finalized the questionnaire and rating score to assess the environmental integrity of rubber plantations in Thailand based on SAFA.

3. Results and Discussion

3.1 Atmosphere
The environmental integrity dimensions have six themes: E1 Atmosphere, E2 Water, E3, Land, E4 Biodiversity, E5 Material and energy, and E6 Animal welfare. The theme E1 Atmosphere had two sub-themes E1.1 Greenhouse gasses (GHG) and E1.2 Air quality. Each sub-theme consisted of indicators. SAFA divided the indicators of environmental integrity into three types, consisting of performance (P), practice-based (R), and target (T) indicators [5]. All of the indicators in theme E1 (Table 1) are included to assess the environmental integrity of rubber plantations. The GHG reduction target was not directly related to rubber farmers. This must be evaluated by the national policy of GHG reduction from an agricultural section. For the GHG mitigation practices, the farmer can employ such practices as optimizing chemical fertilizer use, use organic fertilizer, and not conduct open burning. The sub-theme E1.2 (Table 1) included three indicators. The air pollution reduction target must be assessed by national policy. The Pollution Control Department (PCD) monitors the ambient air quality in all parts of Thailand. This monitoring data can be used to assess the ambient concentration of air pollutants in the plantation area. The farmers could support the air pollution prevention practices by using biofuels such as ethanol and biodiesel and solar cells in the activities related to their rubber plantation.

3.2 Water
Theme E2 Water consisted of two sub-themes, which were water withdrawal and water quality and seven indicators (Table 1) [5]. For the water conservation target and clean water target, these should be proposed by the policymaker. The secondary data on the rain intensity (mm/year) in the rubber plantation area can be used to determine the suitable areas for rubber plantations. A plantation in a low precipitation area is not recommended due to the potential of water scarcity problems and the low production yield. The water stress index value that is evaluated from the ratio of water withdrawal to water availability [7] can represent the water scarcity level in the rubber plantation area. A farmer could support water sustainability by recording the amount of water as the baseline and reducing the amount of water use from the baseline. A storage pond and other structures for storing water in a plantation area should be constructed. The planting of ground cover plants in a rubber plantation area could help to prevent water pollution.

Table 1. Selected sub-themes and indicators for themes E1 Atmosphere and E2 Water for rubber plantations

| Theme          | Sub-Themes               | Selected Indicators                        |
|----------------|--------------------------|--------------------------------------------|
| E1 Atmosphere  | E1.1 Greenhouse Gasses   | E1.1.1 GHG Reduction Target                |
|                |                          | E1.1.2 GHG Mitigation Practices            |
|                |                          | E1.1.3 GHG Balance                         |
|                | E1.2 Air Quality         | E1.2.1 Air Pollution Reduction Target      |
|                |                          | E1.2.2 Air Pollution Prevention Practices  |
|                |                          | E1.2.3 Ambient Concentration of Air Pollutants |
| E2 Water       | E2.1 Water Withdrawal    | E2.1.1 Water Conservation Target           |
|                |                          | E2.1.2 Water Conservation Practices       |
|                |                          | E2.1.3 Ground and Surface Water Withdrawals |
|                | E2.2 Water Quality       | E2.2.1 Clean Water Target                  |
|                |                          | E2.2.2 Water Pollution Prevention Practices|
|                |                          | E2.2.3 Concentration of Water Pollutants   |
|                |                          | E2.2.4 Wastewater Quality                 |
Remark: The themes, sub-themes, and indicators were obtained from SAFA guideline [5]

3.3 Land
The theme E3 Land had two sub-themes E3.1 Soil quality and E3.2 Land degradation [5]. All of the indicators in theme E3 (Table 2) were used to assess environmental integrity. For the soil improvement practices, the farmer must carry out the activities such as using organic fertilizers, applying a soil conditioner, and growing ground cover plants as well as multiple cropping. Soil sampling and analysis are required to assess the physical structure of the soil, soil chemical quality, soil biological quality, and soil organic matter [5]. When the larger area in Thailand was considered, the Land Development Department, Thailand studied the soil properties for all regions in Thailand. This data should be used to determine the sustainability of the soil quality of rubber plantations. In addition, the indirect indicators such as diseases of rubber trees and the number of ants, termites, earthworms can represent the soil quality. The land conservation and rehabilitation plan should be established by the policymaker. The rubber farmer can undertake land conservation and rehabilitation practices such as constructing or maintaining a good irrigation system in rubber plantations and agroforestry.

Table 2. Selected sub-themes and indicators for themes E3 Land and E4 Biodiversity for rubber plantations

| Theme       | Sub-Themes                  | Selected Indicators                                      |
|-------------|------------------------------|---------------------------------------------------------|
| E3 Land     | E3.1 Soil Quality           | E3.1.1 Soil Improvement Practices                        |
|             |                              | E3.1.2 Soil Physical Structure                           |
|             |                              | E3.1.3 Soil Chemical Quality                             |
|             |                              | E3.1.4 Soil Biological Quality                           |
|             |                              | E3.1.5 Soil Organic Matter                               |
|             | E3.2 Land Degradation       | E3.2.1 Land Conservation and Rehabilitation Plan         |
|             |                              | E3.2.2 Land Conservation and Rehabilitation Practices   |
|             |                              | E3.2.3 Net Loss/Gain of Productive Land                  |
| E4 Biodiversity | E4.1 Ecosystem Diversity     | E4.1.1 Land scape/Marine Habitat Conservation Plan       |
|             |                              | E4.1.2 Ecosystem Enhancing Practices                     |
|             |                              | E4.1.3 Structural Diversity of Ecosystems               |
|             |                              | E4.1.4 Ecosystem Connectivity                           |
|             |                              | E4.1.5 Land Use and Land Cover Change                    |
|             | E4.2 Species Diversity      | E4.2.1 Species Conservation Target                       |
|             |                              | E4.2.2 Species Conservation Practices                   |
|             |                              | E4.2.3 Diversity and Abundance of Key Species           |
|             |                              | E4.2.4 Diversity of Production                          |
|             | E4.3 Genetic Diversity      | E4.3.1 Wild Genetic Diversity Enhancing Practices        |
|             |                              | E4.3.2 Agro-biodiversity in-situ Conservation           |
|             |                              | E4.3.3 Locally Adapted Varieties and Breeds             |
|             |                              | E4.3.4 Genetic Diversity in Wild Species                |
|             |                              | E4.3.5 Saving of Seeds and Breeds                       |

Remark: The themes, sub-themes, and indicators were obtained from SAFA guideline [5]

3.4 Biodiversity
Theme E4 Biodiversity consisted of sub-themes: E4.1 Ecosystem diversity, E4.2 Species diversity, and E4.3 Genetic diversity (Table 2) [5]. The farmers can be involved in proposing the landscape and habitat
conservation plants and species conservation target in their rubber plantation area. The rubber plantation practices such as single crops, agroforestry, and growing ground cover plants, and multiple cropping directly affects the biodiversity indicators. The land-use change from the past 20 years and types of land use around the rubber plantation area must be determined in the assessment. The number of rare and endemic species must be determined. The data of rubber verities and the collection of seeds for seedlings are required.

3.5 Material and energy
Table 3 presents the selected sub-themes and indicators for themes E5 Material and energy. The theme E5 Land had three sub-themes E5.1 Material use, E5.2 Energy use, and E5.3 Waste reduction and disposal [5]. All of the indicators in theme E5 (Table 3) are undertaken to access environmental integrity. Theme E5 is directly related to rubber farmer practices. Farmers must plan for the use of alternative energy, recycle and reuse the raw material in the plantation, and reduce the amount of waste. Farmers must keep records of the amount of material, energy, alternative energy use, and waste generated. The generated waste must be managed and disposed of by the proper methods. For the theme E6 Animal welfare, the rubber plantations were not involved in animal products; therefore, animal welfare was not included in the assessment of the environmental integrity of rubber plantations.

Table 3. Selected sub-themes and indicators for themes E5 Material and energy for rubber plantations

| Theme | Sub-Themes | Selected Indicators |
|-------|------------|---------------------|
| E5 Materials and Energy | E5.1 Material Use | E5.1.1 Material Consumption Practices |
| | | E5.1.2 Nutrient Balance |
| | | E5.1.3 Renewable and Recycled Materials |
| | | E5.1.4 Intensity of Material Use |
| | E5.2 Energy Use | E5.2.1 Renewable Energy Use Target |
| | | E5.2.2 Energy Saving Practices |
| | | E5.2.3 Energy Consumption |
| | | E5.2.4 Renewable Energy |
| | E5.3 Waste Reduction and Disposal | E5.3.1 Waste Reduction Target |
| | | E5.3.2 Waste Reduction Practices |
| | | E5.3.3 Waste Disposal |
| | | E5.3.4 Waste Reduction |

Remark: The themes, sub-themes, and indicators were obtained from SAFA guideline [5]

4. Conclusion
This work determined the suitable indicators for assessing the environmental integrity of rubber plantations in Thailand. The system boundary is set to cover rubber plantations, the harvesting of fresh latex, and rubber tree felling. A focus group discussion, using SAFA, guidelines, indicators, and tools for rubber plantations, the review process by rubber plantation experts, representatives of rubber associations, SAFA researchers, and environmental scholars, and the site visit for interviewing rubber farmers in the south, northeast, and north of Thailand were carried out. Environmental themes, including the atmosphere, water, land, biodiversity, and material and energy were included in assessing the environmental integrity of a rubber plantation. Animal welfare was not included. The policymakers must promulgate the plan with the target according to SAFA indicators for supporting the environmental integrity of rubber plantations. According to SAFA indicators, rubber farmers should carry out the recommended activities with the technical and financial support from the governance to get close to sustainable rubber plantations in Thailand.
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