Identifying Suitable Social and Socio-economic Indicators for Biofuel Systems in Thailand

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Abstract: This study aims to identify the suitable social and socio-economic indicators for biofuel systems in Thailand via a literature review also considering criteria for selecting sustainability indicators developed by the Society of Environmental Toxicology and Chemistry/United Nations Environment Program Code of Practice. The concept of life cycle thinking is followed as part these investigations, including, feedstock production, feedstock processing, conversion to biofuel and end use including intermediate transportation. The study was conducted by defining the key stakeholders involved in each unit process of the biofuel systems in Thailand including farmers, suppliers, workers, local community members and consumers. The results of suitable social and socio-economic indicators were aggregated into 9 areas of concern including *farmers*: wage paid, land rights; *workers*: working condition, health and safety, and discrimination; *local community*: local employment, and health and safety; *suppliers*: fair competition; *consumers*: food security. However, further investigations should be performed, especially field surveys, including stakeholder interviews, documenting the quality of data and direct site observations to improve data reliability and robustness.

Keywords: Social indicator, Socio-economic indicator, Biofuel, Sustainability.

1. Introduction

The use of energy in the transportation sector accounts for a large proportion of total energy consumption of society. Being dependent on fossil fuels, it is of major concern for sustainability, particularly vis-à-vis the use of non-renewable resources and greenhouse gas emissions. Alternative fuels have been considered as a solution for decreasing greenhouse gas emissions. The Thai government has initiated policies to promote and utilize renewable energy in the transportation sector; biofuels being one of the priority areas of the national renewable energy policy [1]. However, the increased production of biofuels has raised concerns of their effect on social and socioeconomic aspects. The issues of biofuel production regarding the land acquisition for plantation might be claimed without consideration for its rightful owner. Furthermore, a debate on the effect of biofuel product on the society is growing that concerns about labor right, working condition, health and safety in the feedstock plantation or even company performance in the organization [2]. Sustainability thinking is usually considered to include the environmental, economic and the social aspects as the three pillars. Life Cycle Assessment (LCA) is thus used as an analytical tool for assessing environmental impacts of products over their entire life cycle according to ISO14040. Furthermore, a life cycle costing (LCC) is conducted to find cost-effective over the life of the product system. However, the life cycles of products involving production and consumption also contributes to impacts on the workers, local community, consumers, society and value chain actors. Adaptation for consideration of life cycle based assessment on social aspects can be used as a possible tool for assessment of social impacts and help to bridge the sustainability gap. Social Life Cycle Assessment (S-LCA) is currently interesting and to be under development to include the social dimension. S-LCA is a methodology that aims at assessing the potential social and socio-economic impacts, both positive and negative, of products/services along their life cycle (i.e. from cradle to grave) including extraction and processing of raw materials, manufacturing, distribution, use, re-use, maintenance, recycling, and final disposal as the social LCA guidelines by UNEP [3].

Several studies on social and socio-economic assessment have been conducted, some focused directly on energy/biofuels. An assessment of social and socio-economic LCA developed by the UNEP/SETAC Code of Practice was conducted concerning the production of three major biofuels, including, ethanol, biodiesel and biogas. The assessment was conducted by considering impact categories such as human rights, working conditions, health and safety, cultural heritage, governance and socio-economic repercussions [4]. Although prior efforts have been put in defining and addressing indicators associated to energy production, still many proposed indicators lack adequate criteria for consistent measurement or equitable comparison. For example, the Global Bioenergy Partnership (GBEP) has listed 8 indicators of sustainability for evaluating social aspects [5]. The Roundtable on Sustainable Biofuels (RSB) has also proposed over 100 indicators under seven socio-economic principles but may require additional measurements and analyses [6]. Dale et al. (2013) proposed a small set of clearly defined indicators. A core suite of 10 indicators that can support a measurement of social topics and fall into six categories (social well-being, energy security, trade, profitability, resource conservation, and social acceptability) that are useful to diverse stakeholders [7]. Furthermore, there is a report delivering an appropriate set of social indicators (human rights, working conditions, cultural heritage, social-economic repercussion, and governance) that is useful to assess the sustainability of biofuel, particularly palm oil biodiesel [8].

In the case of Thailand, the study of social impact on biofuel production has previously been evaluated considering socio-economic effect including employment generation, GDP and trade balance from cassava, molasses and sugarcane ethanol and palm biodiesel [9]. A review of existing indicators for social aspects relevant for biomass systems in the East Asian context revealed that the human development index can be used as a national-level indicator [10-11]. However, for the local level, employment generation and access to modern energy were identified as more practical indicators for assessing social impact of biomass energy. A recent study applied employment generation, wages and working conditions, and access to modern energy used to assess social impacts of sugarcane cultivation in the northeastern region as the largest sugarcane producer in Thailand [12].

The goal of this study is to identify social and socio-economic indicators over the entire life cycle of biofuel systems in Thailand by reviewing research papers in the literature, and select suitable indicators by using criteria of indicator selection to

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determine the right indicators that can be used for biofuel business This would be based on considerations of data availability/quality, practicality and measurability, dynamics of social change, and importance of the area of concern. The hypotheses of this study arise from three main questions that will be answered to meet the key objectives as follows:

- Which of the social topics and performance indicators should be used to reflect positive and negative impact of biofuel systems?
- Which stakeholder groups and social topics should be included in the life cycle of biofuel supply chains based on geographical location in Thailand?
- How can the criteria be used to select suitable social and socio-economic indicators?

The boundary of the study is cradle to grave including feedstock production, feedstock processing, conversion to biofuel, end use and all intermediate transportation.

2. Experimental

The methodology of this study follows five main steps as shown in Fig. 1. It consists of goal and scope definition, literature review, data for screening the suitable indicators, using criteria for selecting indicators and, results and discussion. The goal and scope have already been defined in the previous section; the major remaining steps are described as follows:

2.1 Literature review on the key stakeholders throughout the life cycle of fuel systems

Stakeholders who directly obtain the impact over the life cycle of biofuel production would be intended to be studied as the real stakeholder groups [3]. There are six stakeholder groups involved in the study as shown in Table 1 along their respective sector and location [13].

2.2 Screening the current data of social and socio-economic indicators used for biofuel system in Thailand

Table 2 shows the social and socio-economic indicators used for biofuel systems by some recent studies in Thailand. The socio-economic implications of molasses-based ethanol production at a refinery complex were assessed by human development index (HDI) and total value added. HDI is an indicator that has been developed to assess the level of social development at national level; however, there are still limitations in its use as a social indicator at sub-national levels, for example, project level. Since there are large differences of living condition and income among social categories and regions in Thailand, specific information should be collected for the biofuel systems investigated [11]. The social indicators such as employment generation and access to modern energy could be more relevant to capture local impacts of biofuel production [10].

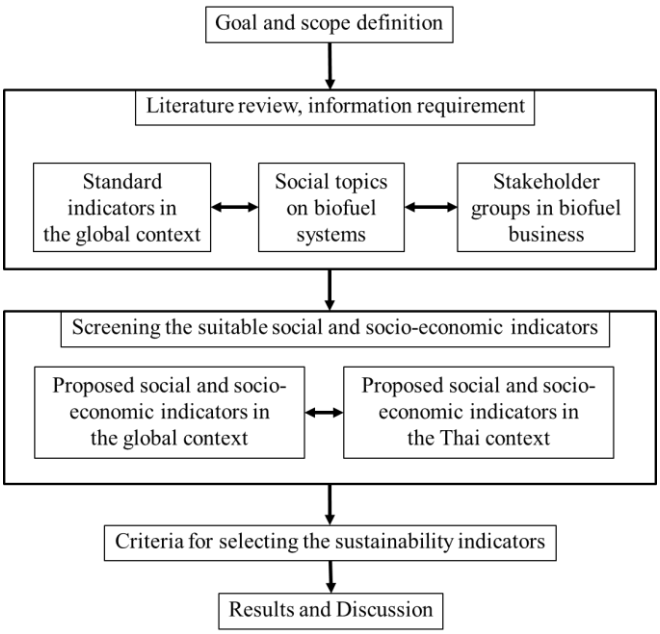

Figure 1 Research framework of this study.

Table 1. Stakeholder groups included in the assessment [13].

	Life cycle stages of biofuel systems				
	Feedstock plantation	Feedstock processing	Biofuel conversion	Transportation	Biofuel usage
Stakeholder addressed	- Farmers - Supplier - Land owners	- Workers - Supplier	- Workers - Supplier	- Workers	- Consumers/ Non-consumers
	Local communities				

Table 2. Social and Socio-economic indicators used for biofuel system in Thailand.

Performance indicators	Measurement approach	References
Socio-economic indicators		
Labor income	Income for self-employed worker (net income from sale of feedstock/no. of self-employed worker) Income for employed worker (total labor cost/no. of employed worker) Total man-days × Average wage per man-days	[11-12]
Total value added	Calculated based on net profit, wages and taxes	[11, 14]
Total net profit	Gross revenue - Cost of intermediate	[14]
Trade balance	Export - Import	[9]
Tax revenues	Total taxable income ×Tax rate	[14]
Foreign exchange earning/saving	Benefit from biofuel exports (revenues from selling) Benefit from biofuel imports (value of import substitute which is generated from reduced diesel imports)	[14]
Social indicators		
Human Development Index	Calculated though life expectancy index, education index and GDP index	[11, 14]
Local employment	Investigated in work hours and converted to full-time equivalent (FTE) jobs per year	[9-10, 14]
Access to modern energy	Access to basic modern energy (electricity, LPG for cooking etc.) Access to knowledge and achievement, health, livelihood and security	[10, 12, 14]
Cultural heritage	Land use change, Culture, Local wisdom	[15]
Labor right	Child labor, Force Labor,	[2, 15]
Food security	Percent change in food price volatility	[7]
Working condition	Working hour, freedom of association and collective bargaining, Health and safety	[12]
Discrimination	Wage for male and female	[12]

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2.3 Criteria for selecting sustainability indicators

In order to select the indicators of biofuel sustainability, five criteria are used based on research in the disciplines related to each category of indicators [7, 17-18]. These criteria can allow the possibility to select the exact indicator that can be used for biofuel system business (Table 3). The different social and socio-economic indicators are characterized according to the stakeholder groups, stating an area of concern, availability of indicator and criteria that can be evaluated by using a symbol(*) based rating system to show the bottleneck level for sustainable biofuel production.

Table 3 Five criteria for selecting sustainability indicators [7, 17-18].

Criteria	Description
1. Data availability/ validity/reliability	The result of the study can be repeatable
2. Practical	Easy, timely and cost effective to measure
3. Measurable	Unambiguous with respect to what is measured and how measurements are made
4. Dynamic to changes	Sensitive and responsive to both natural and anthropogenic stress to system
5. Importance of the area of concern	The severity and frequency of the impact on human welfare

3. Results and Discussion

Based on the data collected from literature review focusing on Thailand context, the proposed indicators were rated accordingly for the following key stakeholder groups, including, (1) *Farmers*: the growers in feedstock plantation; (2) *Supplier*: the providers of fertilizer, material and chemical substances in the biofuel supply chain, such as plantation, transportation and biorefinery plant; (3) *Land owners:* the land ownership and land titles for feedstock plantation; (4) *Workers:* the employees and transporters who work for company or facility of biofuel business; (5) *Consumers/Non-consumers*: the persons who intend to use and get the benefit from biofuel product or the persons who do not use biofuel product but are affected by the emissions from biofuel use in vehicle; (6) *Local communities*: the people who live near the biofuel production sites and are directly affected by both risks and positive impact from biofuel business. The selected areas are considered as sugarcane bioethanol production located in North eastern region (Nakhonratchasima, Khonkaen and Udonthani) as the largest sugarcane plantation areas in Thailand and also biodiesel production located in Southern region as the largest oil palm plantation areas (Chumphon, Suratthani and Krabi) in Thailand. The information from the literature [10, 15-16, 19-20] shows that the social topics in prominent area related as follows:

- *Wage paid*: Lower than the minimum wage of 300 Baht/day [10, 15],
- *Land right*: High levels of tenancy, landlessness and tenure insecurity [10, 15],
- *Access to modern energy*: Lack of access to electricity in the developing countries, especially in the Asia-Pacific region [10],
- *Working condition*: Occurrence of child labor or slave-like labor conditions [19],
- *Human well-being on labor income*: High investment as the result of the effect from natural disasters including, flood problem, drought condition, or pest infestation [10, 15],
- *Health and safety*: Risk of physical and mental problems to workers incurred at work [10],
- *Discrimination*: Inequality of wages for male/female [10],
- *Local employment*: Job creation benefits of biofuel industries and feedstock plantations [10, 15],
- *Access to tangible resource*: Adverse impacts on community access to tangible resources and infrastructure [10],
- *Culture heritage*: Change of indigenous culture of living conditions after adopting the activities in biofuel industries [10],
- *Fair competition*: Unfair business practices such as competitive bid and predatory pricing which could drive competitors out of the market [15] and
- *Food security*: Rise in food prices as a result of biofuel development and policies [16, 19-20]

Stakeholder groups	Social and Socioeconomic indicators	(1) Data availability/ validity/ reliability	(2) Practical	(3) Measurable	(4) Dynamic to changes	(5) Importance of the area of concern
Farmer	Wage paid					
	Land right					
	Access to modern energy					
Worker	Working condition					
	Health and safety					
	Discrimination					
Local communities	Local employment					
	Access to tangible resource					
	Culture heritage					
	Health and safety					
Supplier	Fair competition					
Consumer	Food security					

Note: Color scheme for bottleneck level

Major bottleneck	Medium bottleneck	Minor bottleneck	Data is not present

Figure 2. Bottleneck levels of five criteria for selecting suitable social and socioeconomic-indicators of biofuel systems in Thailand.

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To determine the suitable indicators for Thailand, the social and socio-economic indicators need to be assessed by using the five criteria as shown in Figure 2. All five criteria need to be taken into account in a pragmatic manner. Each of the criteria is given a score on social topics and labeled by using a color scheme.

Figure 2 shows the major areas of concern on social issues based on information available on the proposed indicators in the global context and refined to the context of Thailand. It includes, *farmers*: wages paid, land rights; *workers*: working condition, health and safety, and discrimination; *local community*: local employment, and health and safety; *suppliers*: fair competition; *consumers*: food security. Access to modern energy implies basic modern energy (electricity, LPG for cooking etc.), knowledge and health services. It can reflect quality of life; however, it is relatively difficult to assess the relevant influence by biofuel systems [12]. In addition, land right, access to material and non-material resources and culture heritage are included in the set of access to tangible resources that are considered as a challenge to data availability/validity/reliability for the quantitative approach. The assessment of the risk and impacts on community access to tangible resource is rather difficult. Unlike environmental impacts, different aspects need to be considered including water, land, mineral resources and tangible forms of culture heritage [13]. Most indicators can typically be measured and are practical to use. However, there are no dynamics of social change that refer to behavior or change of status during an interval of time on the social topics of land rights, access to modern energy, working conditions, access to tangible resources, cultural heritage and fair competition. Furthermore, oil palm appears to be pose a considerable threat to food security [15]. However there is no clear and practical measure available for quantifying the effect of biofuels on food price. Indeed, there are some studies suggesting that the food price tends to link to oil prices, weather and local import/export policies [18, 21-22].

An area of concern has been revealed on social topics in biofuel systems based on earlier studies in Thailand. Some desirable indicators require information of decision criteria relevant to practicality, measurability and dynamic to change application; however, the data is not available presently. To progress towards these applications, the methods should be further applied, including stakeholder interviews, documentation of the quality of data and direct site observations to improve data reliability and robustness.

4. Conclusions

The social and socio-economic indicators related to biofuel systems in Thailand were studied via a literature review using criteria for selecting sustainability indicators developed by the Society of Environmental Toxicology and Chemistry/United Nations Environment Programme Code of Practice and supported by literature review.

The proposed social and socio-economic indicators in global context were highly concerned in wage paid, land right, access to modern energy, working conditions, health and safety, discrimination, employment, access to material and non-material resources, culture heritage, fair competition and food security, even though data collection is still challenged by lack of data and low data quality. However, the suites of social and socio-economic indicators need to consider the location-specific social issues which may not always be the same as the global ones.

The major areas of concern on social issues were identified from the information available on the proposed indicators in the global context and then consideration of social topics based on stakeholder of biofuel systems in Thailand. The social topics were aggregated into 9 areas of concern including *farmer*: wage paid, land right; *workers*: working condition, health and safety, and discrimination; *local community*: local employment, and health and safety; *supplier*: fair competition; *consumer*: food security. However further research is needed to study the five criteria comprehensively. Additionally, social topics on biofuel systems need to be verified by site visits based on the same set of social assumptions.

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