化石燃料のバイ オ燃料代替に関する調査、案件発掘及びMRV方法論開発

Biofuel production is widely promoted to enhance energy security and reduce greenhouse gas (GHG) emissions. Many countries promote biofuels as part of their Nationally Appropriate Mitigation Actions (NAMAs), but few biofuel projects have been implemented under the criteria of the Clean Development Mechanism (CDM) of the Kyoto Protocol due to its complicated methodologies, and lack of available data and guidance.

The greenhouse gas (GHG) emissions of biofuels are generally calculated applying the methodology of Life Cycle Analysis (LCA). The net GHG reduction per unit fuel is calculated by comparing greenhouse gas (GHG) emissions related to biofuels production and utilization with conventional diesel and gasoline production from mineral oil and the emissions related to reference land use. However, widespread deforestation in the Asia-Pacific region associated with biofuels production indicates that assessment of biofuels should not just be limited to a life cycle analysis of GHG emissions. Environmental and social factors must also be considered.

実施内容

Under the Alternative Energy Development Plan, the Government of Thailand has set a target of increasing biofuels production. Agricultural areas under rice cultivation have been converted to biofuel feedstocks, due to the increased demand for bioethanol. Biofuels can contribute to climate change mitigation by providing a substitute for fossil fuels, but biofuel production also impacts the livelihoods of farmers, in terms of both the financial benefits and the opportunity costs of alternative land uses. Biofuels production can also impact the local environment through the chemical inputs required to achieve high crop yields. A multidimensional framework for understanding the impacts of biofuels production in Thailand is required.

The objectives of this study were: to analyze the scale and location of land use changes associated with biofuels production; to assess advantages and disadvantages of each biofuel crop against alternative land uses in terms of environmental and socio‐economic factors, and mitigation potential; and to contribute to the development of methodologies for estimating biofuel GHG mitigation potential by integrating analysis of land use change into life cycle assessment.

実施期間

平成 25 年 4 月 25 日～平成 26 年 3 月 22 日

調査の実施場所

タイ.バンコク.コンケン

分析

The sustainability of bioethanol production from sugarcane and cassava, and charcoal from eucalyptus was assessed from the viewpoints of production efficiency, greenhouse gases (GHG) mitigation, local environmental impacts, and socio-economic welfare (figure 1). In terms of the life cycle of biofuels, the study covered production, transportation of feedstocks, processing and transportation of biofuels stages.

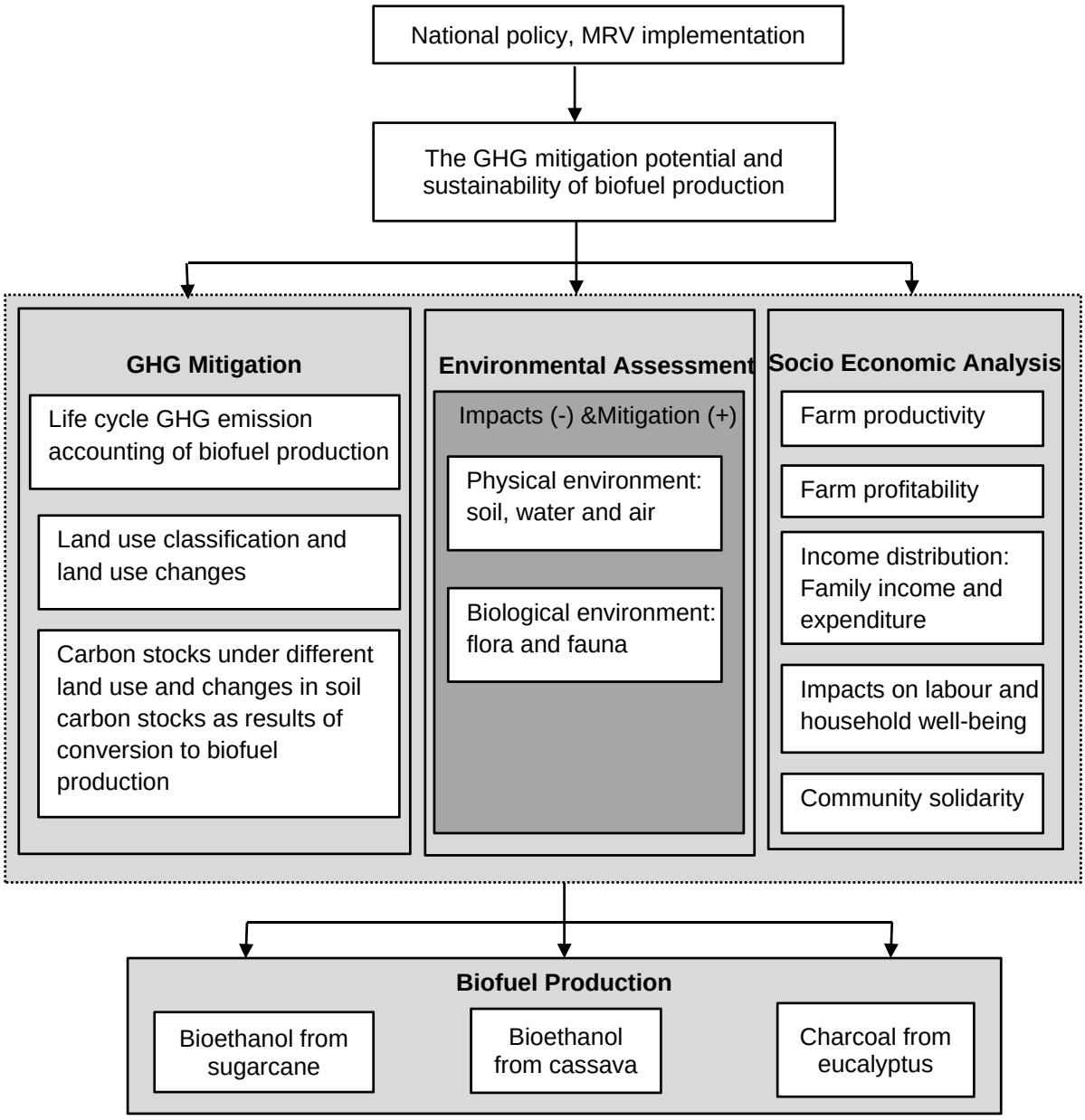

Figure 1 Conceptual framework

Source: Authors, 2013

The methodology proposed and tested for evaluating biofuels production in Thailand included:
1) Land use and land use change associated with biofuels production
2) GHG emission calculation
3) Environmental impact assessment
4) Socio-economic sustainability assessment

Five questionnaires were designed to collect primary data in three districts in Khon Kaen Province, as follows.
1) Questionnaire for GHG Emissions Assessment of Ethanol Production from Sugarcane
2) Questionnaire for GHG Emissions Assessment of Ethanol Production from Cassava
3) Questionnaire for GHG Emissions Assessment of Charcoal Production from Eucalyptus

4) Questionnaire for Environmental Impacts Assessment of Growing of Biofuel Feedstocks
5) Questionnaire for Socio-Economic Sustainability Assessment of Growing of Biofuel Feedstocks and Processing

A total of 91 biofuel crop farmers cultivating sugarcane, cassava, and eucalyptus were interviewed from September to October 2013.

The study provides guidance on (i) GHG emission calculation and lists the emission factors used, (ii) assessing land use changes associated with the production of biofuel feedstocks by applying GIS, (iii) conducting profitability analysis of biofuel crops, and (iv) assessing other environmental and socio-economic impacts of biofuels.

実施結果

The proposed methodology was applied to assess the GHG mitigation potential and sustainability of bioethanol production from sugarcane and cassava and wood charcoal from eucalyptus in Khon Kaen Province, Thailand. The study shows that increasing biofuel crop demand reduced the land available for rice and other field crop cultivation in the study sites over the last decade. The expansion of the growing area of sugarcane, cassava, eucalyptus, and para rubber has been especially significant.

The study analysed the amount of carbon stocks stored by the major biofuel crops in the study sites. The total carbon stock of sugarcane was found to be the highest. In terms of GHG emissions during cultivation, harvesting, transportation of raw materials to mill, and biofuel processing and transportation, biofuel processing was found to be the largest source for ethanol production using cassava, and the conversion of rice land to sugarcane was the largest source for ethanol production from molasses.

As molasses and cassava are the main raw materials in the ethanol production, the emissions from molasses ethanol production was compared to the emissions from cassava ethanol production under different scenarios in figure 2: scenario 1 included emission saving from soil carbon accumulation due to improved agricultural practices (E_{sca}) and scenario 2 excluded E_{sca}. The results show that the emissions from the extraction or cultivation of input materials (E_{ec}) and emissions from carbon stock changes caused by land- use change and management (E_l) for molasses ethanol production in both scenarios were higher than the emissions from the cassava ethanol production, but the emission credits from molasses ethanol production were greater due to the excess electricity from the sugar milling. There were differences in the levels of emissions according to the type of fuel used. The emissions from charcoal used in the cassava ethanol production was higher than the emissions of bagasse used in the molasses ethanol production.

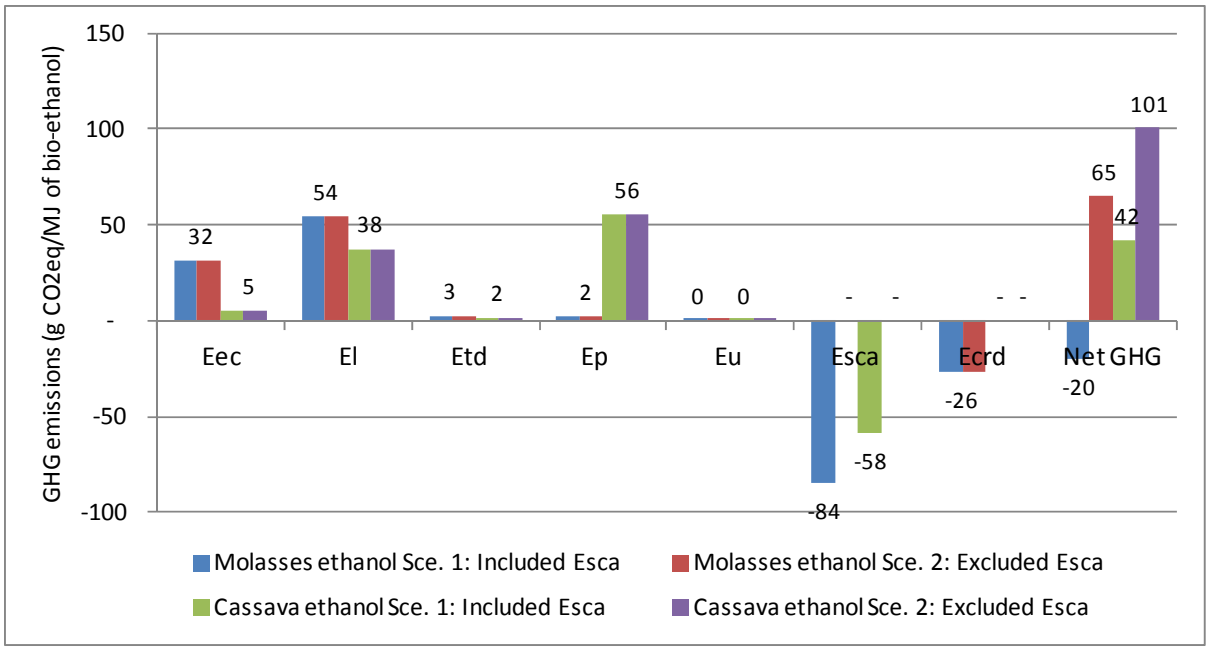

Figure 2 Comparative Life cycle GHG emissions of molasses and cassava ethanol

This study showed that production of biofuels in Thailand can produce net GHG emissions reductions, and so can be considered as part of an offsetting strategy. Of the biofuel processes studied, it appears that mitigation potential is highest for ethanol produced from molasses, followed by ethanol from cassava. Table 1 shows the GHG saving potential of molasses and cassava ethanol compared to gasoline for transport under scenario 1 (E_{sca} included) and scenario 2 (E_{sca} excluded). In scenario 1, the emissions were reduced by 124% for the use of molasses ethanol and by 50% for the use of cassava ethanol. However, it should be noted that the emission performance of biofuels can be influenced by factors with a wide rage results (Silalertruksa and Gheewala 2011). The critical factors are types of land-use changes, types of fuel used in the ethanol plants, crop productivities and approaches to manage the residues from the biofuel production system. A recent study in Thailand has indicated that net emission reduction of cassava ethanol compared to gasoline ranged from 73% reduction to 250% increase of GHG emissions, and the emission reduction of molasses ethanol ranged from 77% reduction to 320% increase of GHG emissions (Silalertruksa and Gheewala 2013). The worst case scenarios include forest land converted to cropland and poorly performing ethanol plants.

Table 1 Emission saving from the use of biofuels in comparison with the use of fossil fuels

Types of Biofuels	**EM of fossil fuels – EM of biofuels**		
	Purposes	**GHG saving potentials (g CO_2eq/MJ)**	**% EM saving potential**
Sugarcane molasses ethanol - Scenario 1: Included E_{sca} - Scenario 2: Excluded E_{sca}	For transport	[83.8 – (-20)] = 104 [83.8 – 65] = 24	124% 29%
Cassava ethanol - Scenario 1: Included E_{sca} - Scenario 2: Excluded E_{sca}	For transport	[83.8 – 42] = 42 [83.8 – 101] = (-17)	50% (-20%)
Eucalyptus charcoal	For heat	[77 – (-2)] = 79	102%

- Scenario 1: Included E_{ec} , E_l - Scenario 2: Excluded E_{ec} , E_l	production	[77 – 0.4] = 76	100%

The proposed methodology also considers local environmental impacts and household well-being to be important factors in determining the sustainability of biofuel feedstock production. Most of the surveyed farmers participate in farmer organizations, which provide production inputs and credit for their farm activities. Economic analysis of biofuel crop farming revealed that the average cost of sugarcane farming was higher than cassava and eucalyptus because of increased use of chemical inputs for improvement in yield and production efficiency.

As a result of the chemical inputs, sugarcane cultivation has the highest negative impacts on the environment. Most of the surveyed farmers in the study sites strongly agreed that biofuel crop farming has negative environmental impacts, especially in terms of decreased soil fertility, increased disposal of waste water in rivers, and increased impacts on health because of the intensive application of chemicals inputs. Nevertheless, some farmers planned to expand the cultivation of sugarcane, because it attracts the highest profits.

Overall, using the proposed methodology the results suggest that sugarcane production has net climate benefits (emissions throughout the lifecycle are lower than for fossil fuels) and that cultivating biofuel crops contributes to the social and economic welfare of households. However, biofuel crop cultivation has reduced the area available for other crops, which has implications for the national goals for rice production, etc., and the heavy use of chemical inputs for sugarcane production is detrimental to the environment and human health. These observations highlight the importance of using a comprehensive assessment methodology for biofuels that includes environmental and socio-economic factors.

The following recommendations are based on these results:

- Biofuel crop cultivation is contributing to rural livelihoods and to meeting Thailand's energy needs; however, the Thai Government should encourage agricultural zoning to avoid deforestation and ensure that its policy on biofuels does not undermine its food security;
- To increase the mitigation potential of biofuel production, ethanol processing plants should substitute imported coal used in their operations with energy generated from biomass and/or biogas;
- The Thai Government should provide capacity to Thai farmers to use improved agricultural practices that increase yields, reduce reliance on chemicals, and make use of cane trash and by-products.

添付資料

【資料1】化石燃料のバイ オ燃料代替に関する調査、案件発掘及びMRV方法論開発
（該当章抜粋）
Towards a comprehensive methodology to assess biofuels production as a climate change mitigation action: Climate Benefits and Environmental and Socio‐Economic Implications of Biofuels production in Thailand

【資料 2】Proposed methodology

【資料 3】Applying the proposed methodology