Energy for Sustainable Development 29 (2015) 100–111

Contents lists available at ScienceDirect

Energy for Sustainable Development

Does palm biodiesel driven land use change worsen greenhouse gas emissions? An environmental and socio-economic assessment

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ARTICLE INFO

Article history:
Received 16 February 2015
Revised 18 August 2015
Accepted 21 October 2015
Available online 12 November 2015

Keywords:
Biodiesel
Land use change
Greenhouse gas emission
Socio-economic impacts
Eco-efficiency

ABSTRACT

Biodiesel is widely promoted to replace conventional diesel based on considerations of energy security, resource depletion, and global warming mitigation. The extent of greenhouse gas emissions may vary depending upon the type of land area converted for biodiesel crop cultivation. In addition, the economy and society are also affected both positively and negatively. The objectives of the study are to 1) evaluate the effect of biodiesel demand in Thailand on types of crops, 2) estimate the magnitude of change in both land area and prices of the converted crops, and 3) assess sustainability by integrating environmental and socio-economic impacts associated with land use change. Correlation analysis, multiple regression, econometric modeling, and eco-efficiency are used in evaluating crops affected as well as percentage changes in the converted crop area and crop prices, and the sustainability of biodiesel, respectively, as the Royal Thai Government targeted in the Renewable and Alternative Energy Development Plan (AEDP). The study revealed that coffee, rambutan and rice are significantly affected by oil palm expansion. Consequently, the greenhouse gas emissions due to land use change arising from the AEDP are projected to be lower than without land use change. The socio-economic impacts cover positive impacts, i.e., currency savings and increases in farmers' income due to higher prices of oil palm, and negative impacts, i.e., increases in prices of foods, such as bottled palm oil, and biodiesel for energy use. Compared to conventional diesel (B0), the net socio-economic impact of 2% biodiesel (B2) is better, but 5% (B5) and 10% (B10) are worse. When land use change is integrated, the net socio-economic impacts of B5 and B10 become better than those of B0. The eco-efficiency analysis shows that biodiesel blends at 9% would be the optimum.

Introduction

According to the new 10-Year Renewable and Alternative Energy Development (AEDP: 2012–2021) Plan, the Royal Thai Government targeted a biodiesel requirement for the energy sector of approximately 6 ML/day by 2021, and planned to increase the blending ratio up to 10%, or B10 (Department of Alternative Energy Development and Efficiency, 2012). An increased demand for bioenergy affects agricultural systems and food prices. The effects on the value chain of palm oil associated products and on different groups of people can be both positive and negative. Furthermore, when profit from biomass plantations exceed profit from food production, farmers will react by substituting energy crop cultivation for food crop cultivation unless prices for agricultural commodities increase (Johansson and Azar, 2007; Schnepf, 2005). Because agricultural land area is limited, comparative benefits of land use will change, resulting in changes in the structure of agricultural crop production. The rise in price of the energy crops encourages farmers to grow more energy crops (Johansson and Azar, 2007; Schnepf, 2005; Kløverpris et al., 2008a; Fritsche et al., 2010; Ubolsook, 2010). This altering of the structure of agricultural crop production demonstrates that Thai farmers made their choices based on economic factors; they substituted cultivation of higher value, more profitable crops for cultivation of less profitable crops such as rice. The high price of oil palm fresh fruit bunch (FFB) can motivate farmers to invest in oil palm production because they expect that it would be profitable as a long-term investment due to an economic life cycle of more than twenty-five years. Factors that significantly influence oil palm plantation areas are domestic demand for crude palm oil, farm prices of oil palm FFB, prices of diesel oil, and farm prices of unsmoked rubber sheet grade 3 (Phitthayaphinant et al., 2012). This change, in addition to the trend of increasing prices for fossil fuels, garnered support in Thailand and many other nations (Kongrithi and Isvilanonda, 2009). Furthermore, as an effect of the expansion of biofuel production, there is a danger of causing environmental damage to developing regions with delicate, peripheral land or high-value forests. Thus, the directions of crop conversion both in crop types and their magnitudes are very important for the sustainability assessment of biofuels because the types

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http://dx.doi.org/10.1016/j.esd.2015.10.005
0973-0826/

and the area of the converted crop would affect the environmental and socio-economic impacts.

To reduce disputes over land use, the stipulation of economically sound and environmentally feasible choices is necessary for optimal land utilization, also in regards to socio-economic effects, and to promote sustainable bioenergy sources (Fritsche et al., 2006). There are several indicators for assessing each category of environmental, social and economic performance. For sustainability assessment, all three categories need to be assessed in tandem to avoid unintended tradeoffs among them. The goals of the study are 1) to evaluate the effects of biodiesel demand on land use change (LUC) for feedstock cultivation, 2) to estimate the magnitude of change both in area and price of the converted crops caused from the biodiesel targeted in the new 10-Year Renewable and Alternative Energy Development (AEDP: 2012–2021) Plan, and 3) to assess sustainability by integrating environmental and socio-economic impacts from the entire life cycle of biodiesel combined with those impacts caused by LUC.

Methods

Essentially, three main methods exist for increasing the production of a given crop: reduced production of other crops, increases in land use for the crop, and improvements in existing crop yields (Kløverpris et al., 2008b). A study conducted by Salvatore and Damen (2010) indicates that the increase in oil palm production in Thailand will result mostly from increased land use. The size of these effects fundamentally depends on the quantity of biomass produced by ecosystems each year. Increases in demand for bioenergy have two major effects on land use change: a direct effect on bioenergy itself, and an indirect effect on other crops. The effects of land-use changes result in both socio-economic and environmental concerns (Miyake et al., 2012; Ubolsook, 2010). Susanto et al. (2008) analyzed the effect of ethanol production on land area of corn planted using regression analysis, where the area planted is a function of the relative price ratio of competing commodities. The study demonstrated that a proportionally large increase in corn prices resulted in significant increases in land use for corn. Their findings are support the findings of a study conducted by Ubolsook (2010) that developed a partial equilibrium econometric model to forecast the effects of a rise in the production of ethanol on the agriculture sector of Thailand over the next decade. The model is applied to three different scenarios were modeled to analyze the impacts of government targets for ethanol production. The predictions of the model and analysis of different production targets were that an increase in the production of ethanol results in a rise in the price of cassava. An increase in cassava prices encourages farmers to increase production of cassava while decreasing their production of other crops. The study also indicated that maize and sugarcane, which are competing crops with similar land use requirements, are displaced by cassava crops. With a reduction in quantity produced, the price of maize tends to rise in the future.

Converting competing crops from food crops to energy crops causes less supply of such crops. Economically, those converted crop prices may be higher and consequently, may positively affect those producing the remaining supply of those crops, while negatively affecting consumers. There have been numerous full life cycle studies taking into account emissions from direct land use changes but none of them reports the magnitude of area and price changes (Siangjaeo et al., 2011; Silalertruksa and Gheewala, 2012).

Scope and functional unit

The scope is the entire life cycle of biodiesel blends covering the stages of feedstock production, transportation, production process, product use, and LUC, as shown in Fig. 1.

Functional unit: the amount of 21,000 million L of biodiesel blends per year which is derived from the biodiesel (B100) demand of 6 ML/day for the highest biodiesel blending ratio at 10% targeted in the AEDP serves as the functional unit. The blending ratios are 2%, 5% and 10%, represented as B2, B5 and B10, respectively.

The socio-economic impacts cover positive impacts, i.e., currency savings and increases in farmers' income due to higher prices of oil palm, and negative impacts, i.e., increases in prices of foods, such as bottled palm oil, and biodiesel for energy use.

Since deforestation is illegal in Thailand (Siangjaeo et al., 2011; Silalertruksa and Gheewala, 2012), forest area is excluded from the converted land.

Biodiesel production in Thailand

Crude palm oil (CPO) from fresh fruit bunch (FFB) of oil palm is the main feedstock for biodiesel (B100) production in Thailand. Typically, the biodiesel production process is trans-esterification of CPO with methanol (MeOH) and sodium hydroxide (NaOH) as catalyst which produces palm oil methyl ester (B100) and glycerol.

The biodiesel industry is comprised of 9 manufacturing plants with the capacity of 1.55 ML/day. Oil palm is cultivated mainly in the southern parts of Thailand — Krabi, Suratthani, Chumporn and Trang provinces.

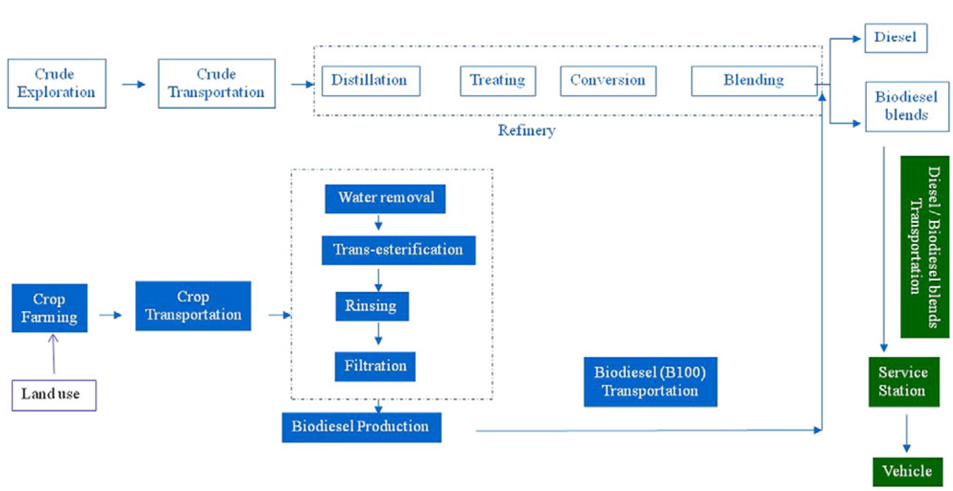

Fig. 1. System boundaries for diesel and biodiesel.