Chapter 2

WG Methodology and Summaries of Pilot Studies in Selected East Asian Countries

Sustainability Assessment of Biomass Utilisation in East Asia Working Group

November 2011

This chapter should be cited as
Sustainability Assessment of Biomass Utilisation in East Asia Working Group (2011), 'WG Methodology and Summaries of Pilot Studies in Selected East Asian Countries' in *Sustainability Assessment Methodology for Biomass Energy Utilisation for Small and Large Scale Initiatives: Lessons Learned from Pilot Studies in Selected East Asian Countries*, ERIA Research Project Report 2010-22, Jakarta: ERIA, pp.11-23.

2. WG METHODOLOGY AND SUMMARIES OF PILOT STUDIES IN SELECTED EAST ASIAN COUNTRIES

2.1. WG Concept

The WG adopted the definition of "sustainable development" from "Our Common Future" of the United Nations World Commission on Environment and Development report published in 1987 (WCED, 1987), i.e., "development that meets the needs of the present without compromising the ability of future generations to meet their own needs".

The triple bottom line approach, focusing upon "people, planet, profit", is based upon social, environmental and economic criteria. To ascertain the sustainability of biomass energy development, these aspects are necessary and must be considered to overcome and minimise the problems that may occur with the expansion of biomass energy utilisation. In view of these, the WG has developed a methodology to assess sustainability of biomass utilisation in the East Asian context considering environmental, economic and social pillars.

2.2. WG Methodology to Assess Sustainability of Biomass Utilisation

The WG methodology to assess sustainability of biomass utilisation is briefly described in this section. For the details of the WG methodology, please refer to (Sagisaka, 2009).

2.2.1. Environmental Indicator

Life cycle assessment (LCA) is increasingly being promoted as a technique for analysing and assessing the environmental performance of a product system and is suited for environmental management and long-term sustainable development. Although LCA can be used to quantitatively assess the extent of impact of a product system towards environmental issues of concern such as acidification, eutrophication, photo-oxidation, toxicity and biodiversity loss, these impact categories are currently not as much in the limelight as climate change, a phenomenon that is associated with the increasing frequency of extreme weather conditions and disasters. Effects of climate change have been attributed directly to the increased atmospheric concentration of GHG released by anthropogenic activities. Taking other standards or frameworks for biomass energy sustainability into consideration, the WG adopted life cycle GHG emissions that can be quantified through life cycle inventory (LCI) analysis using the collected foreground and background data as the indicator to evaluate the environmental sustainability of biomass energy utilisation.

The system boundary for LCI is comprised of three stages: feedstock cultivation, feedstock collection and biomass energy production. There is a wide recognition that the effect of land use and land use change (LULUC) towards the life cycle GHG emissions could be significant. Although their effect can be calculated using equations and default values proposed by the International Panel on Climate Change (IPCC, 1997), the WG recognises that there is still limited consensus on various aspects of methodology and conversion factors used in the calculations. Studies are still on-going and expected to provide more scientific evidence of the appropriate values that can be adopted to calculate the GHG emissions associated with LUC in future.

Hence the emissions from LUC are excluded from the system boundary of the present WG's methodology. However, future considerations for relevant environmental impacts, especially on losses of carbon stock from land use change (LUC), will be included to complete the sustainability assessment of biomass cultivation and utilisation. Therefore in this report, the concept of GHG emission by LUC and its calculation methods are described in 4.1.2.

The LCI for biomass energy should cover CO_2 and non-CO_2 GHGs, namely CH_4 and N_2O that are released directly and indirectly from agricultural activities. The GHG inventory is calculated as CO_2 equivalent (CO_2eq) and the summation of contribution from non-CO_2 GHGs are based upon the IPCC Fourth Assessment Report (AR4) Global Warming Potential (GWP) values for a 100 year horizon (IPCC, 2007).

2.2.2. Economic Indicator

Economic sustainability of biomass utilisation relates to the exploitation of biomass resources in a manner by which the benefits derived by the present generation are obtained without depriving such opportunity to the future generations. In the assessment of sustainability, it is equally important to determine the actual level and degree of the economic benefits brought about by the biomass industry. Specific economic indices would have taken into consideration to measure the scope of the benefits. Existing methodologies in quantifying such indicators would have to be adopted and evaluated as well. Economic indicators ultimately provide an accurate measurement of the economic performance of a particular industry such as biomass. Based upon the various literature reviewed, the most common economic contributions of biomass utilisation are value addition, job creation, tax revenue generation and foreign trade impacts. The same indicators were taken into consideration to evaluate economic sustainability of biomass energy utilisation in WG's methodology: 1) total net profit accumulated from product conversion or processing; 2) personnel remuneration created by employment at the biomass industry; 3) tax revenues generated from the different entities within the industries; 4) foreign trade impacts in terms of foreign exchange earnings and savings; and 5) total value added, which is the sum of all the previous indicators. Each indicator can be calculated by the following equations:

Total net profit (TNP) = Total returns – Total costs (2-1)

where

Total returns = Sales from primary output + Sales from by-products (2-2)

Total costs

= Amount of material inputs used + Labour costs + Overhead costs (2-3)

Overhead costs = Taxes and duties + Interest + Depreciation (2-4)

Personnel remuneration

= Total man-days (Employment) × Average wage per man-days (2-5)

where

$$\text{Wages} = \text{Wage rate} \times \text{Labour requirement} \tag{2-6}$$

$$\text{Tax revenue} = \text{Total taxable income} \times \text{Tax rate} \tag{2-7}$$

where

Total taxable income

$$= \text{Income from main product} + \text{Income from by-product} \tag{2-8}$$

Income from main product

$$= \text{Profit per unit of main product A} \times \text{Volume of A} \tag{2-9}$$

Income from by-product

$$= \text{Profit per unit of by-product B} \times \text{Volume of B} \tag{2-10}$$

Net foreign exchange earnings

$$= \text{Reduced foreign exchange earnings from product exports}$$

$$+ \text{Foreign exchange savings from reduced imports} \tag{2-11}$$

where

Foreign exchange earnings

$$= \text{Price per unit of convertible material} \times \text{Total volume of exports} \tag{2-12}$$

Foreign exchange savings

$$= \text{Amount of biomass}$$

$$\times \text{Foreign exchange savings per unit fossil fuel replaced} \tag{2-13}$$

Total value added (TVA)

$$= \text{Total net profit} + \text{Personnel remuneration}$$
$$+ \text{Tax revenue} + \text{Net foreign exchange earnings} \quad (2\text{-}14)$$

2.2.3. Social Indicator

Social issues in the growing markets for biomass energy are expected to become prominent as the producers and consumers of biomass energy may belong to different countries. Major social benefits of biomass energy include greater energy security, employment opportunities and improved health from reduced air pollution. On the other hand, possible negative social impacts of biomass energy, such as food insecurity, need to be considered seriously. While there could be some relief on the energy front, the food insecurity and food prices, particularly in developing economies, may aggravate the negative social impact on people.

Measurement of social development differs significantly from economic development. Also, compared to indicators of social development, indicators of economic development are available for most of the countries. However, in many cases, particularly in developing economies, economic indicators often reflect a rosy picture that is far away from the reality. To capture the holistic picture of development across countries, the United Nations Development Programme (UNDP) has used the Human Development Index (HDI). This essentially takes into account the measures for living a long healthy life (by life expectancy), being educated (by adult education and enrolment at primary, secondary and tertiary levels) and having a decent standard of living (by purchasing power parity, PPP). The WG adopted HDI as the indicator to evaluate social sustainability of biomass energy utilisation. The calculation of HDI can be described as equation (2-15) and Table 2-1. Although the calculation of HDI has changed in the UNDP report published in 2010 (UNDP, 2010), please note here that the WG's calculation is based upon the previous report (UNDP, 2008).

$$HDI = 1/3 \times (\text{Life expectancy index} + \text{Education index} + \text{GDP index}) \qquad (2\text{-}15)$$

Table 2-1. Calculation of HDI

Index	Measure	Minimum value	Maximum value
Life expectancy	Life expectancy at birth (LE) LE index = $(LE-LE_{min})/(LE_{max}-LE_{min})$	25 years	85 years
Education	Education index = ALI×2/3+GEI×1/3 Adult literacy index (ALI) = $(ALR-ALR_{min})/(ALR_{max}-ALR_{min})$ where ALR: Adult literacy rate [%] Gross enrolment index (GEI) = $(GER-GER_{min})/(GER_{max}-GER_{min})$ where GER: Gross enrolment ratio [%]	0%	100%
GDP	GDP index = $\{\ln(GDP)-\ln(GDP_{min})\}/\{\ln(GDP_{max})-\ln(GDP_{min})\}$ where GDP: GDP (PPP) per capita [USD]	100 USD	40,000 USD

In addition to HDI, some other social development indicators (SDIs) such as Gender-related Development Index (GDI) are also calculated to assess the condition of women in terms of social development as a result of biomass resources utilisation for energy. Please refer to (ERIA, 2010) for the details.

2.3. Target Users of the Methodology and Results

As our WG methodology intends to be used in EAS countries to assess sustainability of biomass utilisation for energy in accordance with the guideline, the situations where the methodology is expected to be used are as follows:

Case 1: Sustainability assessment of a biomass utilisation project being planned.

Case 2: Comparative analysis of sustainability of several options of a biomass project being planned

Case 3: Sustainability assessment of an ongoing biomass utilisation project

Case 4: Comparative analysis of several options to improve sustainability of an ongoing biomass project

The WG methodology aims at both ex ante and ex post evaluation of sustainability utilisation of biomass for energy. In the above cases, users of the results obtained through the WG methodology are the decision makers who have the right to make decisions on whether or not the biomass utilisation initiatives are introduced/carried on, including politicians in charge of biomass project policy and stakeholders such as owners of farms or plantation fields, factory managers, etc.

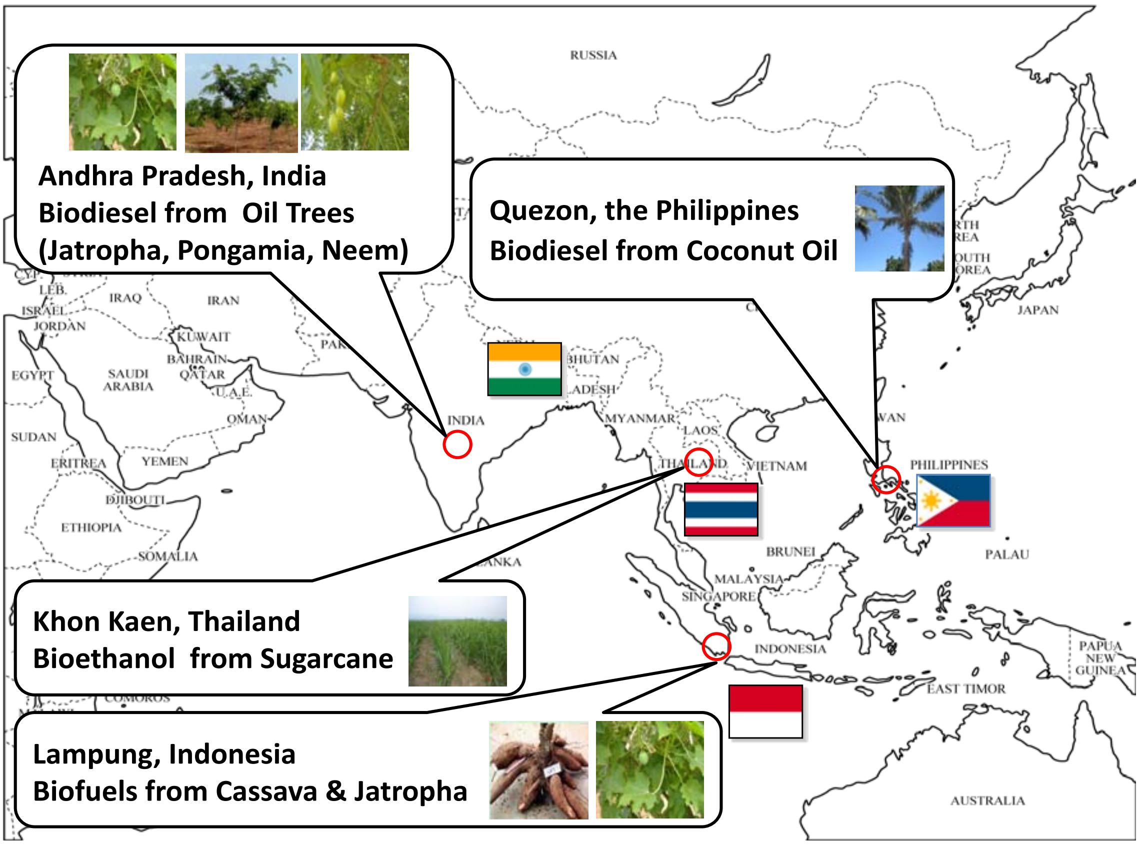
On the other hand, direct users of the methodology, who will be asked by decision makers to assess the sustainability of biomass initiatives and to report the results of the assessment, would be: academics; consultants; and technical officers.

2.4. Brief Summary of Pilot Studies in Selected East Asian Countries

Four pilot studies have been implemented by designated organisations under the ERIA's framework to apply and field-test the assessment methodology developed by the WG. One case study was implemented in each selected East Asian country, namely, India (Andhra Pradesh), Indonesia (Lampung), the Philippines (Quezon) and Thailand (Khon Kaen), as shown in Figure 2-1.

In each pilot study, more than hundred sets of data were obtained through interviews, calculations based upon primary data collected from pilot study sites, and secondary data from elsewhere to calculate the environmental, economic and social indicators of sustainability of biomass energy utilisation according to the WG methodology. The brief summaries of each pilot study are addressed in this section. Please refer to the WG report (ERIA, 2010) for the details.

Figure 2-1. Location of Four Pilot Studies with Different Feedstocks for Biomass Energy



2.4.1. Pilot Study in Andhra Pradesh, India

In case of India, economic assessment indicates that cost incurred during the Jatropha cultivation stage is much higher than the revenue generated, which is not economically viable. At the biodiesel production stage, both total value added (TVA) and total net profit (TNP) are quite attractive, provided the raw material is available at a reasonable price. During the lifecycle of biodiesel production process, a TVA of 80,331 INR or 1,674 USD and a net profit of 39,531 INR or 824 USD per hectare per year were estimated. On the environmental front, companies expect some carbon saving and an additional revenue from carbon credits. GHG saving potential estimated during the process shows a net carbon saving of 2,771,681 t-CO_2eq per year. On the social front, several positive results are visible during various stages of biodiesel production, the main being employment generation for local people increasing their income, which may result in an overall improvement in their living standard.

2.4.2. Pilot Study in Lampung, Indonesia

Biomass energy program in Indonesia was carefully designed but was not running as smoothly as planned originally. It was observed that the cassava utilisation for ethanol in Lampung Province is facing a competition for raw material from tapioca factories. Environmental assessment shows that during bioethanol production GHG emissions depend upon whether the biogas from wastewater treatment is flared or not. Economic assessment indicates that processing cassava for bioethanol increased the value added of cassava by about 950-1,108 IDR or 0.103-0.120 USD per litre of bioethanol or about 146.6-171 IDR or 0.0159-0.0186 USD per kg of cassava. For social assessment, the HDI values for cassava farmers in the study region were estimated to be lower than the HDI values for North Lampung, in general. In case of Jatropha biodiesel, although farmers in the target village receive a very low benefit from cultivation stage, utilisation of Jatropha waste increased their earnings significantly. Environmental assessment indicates that GHG emissions from Jatropha plantation and crude Jatropha oil processing were 59% and 82% of total emissions, respectively. Waste utilisation for biogas production was able to reduce GHG emissions by 41% of total emissions. HDI estimates for Jatropha farmers in North Lampung indicate that quality of life, education, and income for the people in the village were quite low.

2.4.3. Pilot Study in Quezon, the Philippines

Economic analysis of the Philippines study shows that considering the production costs and revenues for each product, the net profit per unit of product is highest for copra production (at 6.76 PHP or 0.150 USD per kg) and lowest for coconut methyl ester (CME, biodiesel from coconuts) production (at 0.122 PHP or 0.0027 USD per litre). The cumulative total profit for all product forms is about 38,000 PHP or 844 USD per ha and the TVA from the biodiesel industry in the province of Quezon would be 13.74 billion PHP or 305 million USD. The use of coconut methyl ester to replace petro diesel will result in net savings or GHG emission reduction of 2,823.97 kg-CO_2eq per ha per year. In terms of social indices, the computed HDI is 0.784 while the change in HDI is 0.004 indicating a higher level of social development. In terms of living standard, the majority (66%) of coconut farmers perceived that there has been an improvement in their living conditions due to coconut farming. In general, the results show that majority of the employees benefited from their respective employment in the biodiesel production chain.

2.4.4. Pilot Study in Khon Kaen, Thailand

In the Thailand study, environmental assessment for the lifecycle of ethanol production indicates that the overall GHG emissions associated with the ethanol production and consumption stages are slightly lower but not significantly different from that of gasoline. Increasing the utilisation of the materials produced during various unit processes in the biorefinery complex results in reducing the GHG emissions. Economic assessment of the overall process of bioethanol production indicates that the TVA for the whole biorefinery complex amounts to 3,715,458,551 THB or 116,108,080 USD and it is economically viable. For social assessment, the HDI of the sugarcane plantation, biorefinery complex, and Khon Kaen were observed as 0.736, 0.797 and 0.763, respectively. Thus, although sugarcane farmers have a lower social development than an average person in Khon Kaen or employee at the biorefinery complex, they still benefit from a steady income as a result of the contract farming, which links them to the sugar mill and guarantees an annual income. Employees at the biorefinery have a higher social development (shown by a positive change of 0.034 in HDI) as compared to the Khon Kaen.