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SUSTAINABILITY ASSESSMENT OF BIOMASS ENERGY UTILISATION IN SELECTED EAST ASIAN COUNTRIES

Edited by
ERIA WORKING GROUP ON
"SUSTAINABILITY ASSESSMENT OF BIOMASS UTILISATION IN EAST ASIA"

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ABBREVIATIONS AND ACRONYMS

Currency Conversion Rates used in this Report:

1 USD = 48 INR = 45 PHP =32 THB = 9200 IDR (approximately)

ALR	Adult Literacy Rate
ASEAN	Association of South - East Asian Nations
AP	Andhra Pradesh (an Indian State)
CER	Certified Emission Receipts
CH_4	Methane
CJO	Crude Jatropha Oil
CME	Coconut Methyl Ester
CNO	Crude Coconut Oil
CO_2	Carbon Dioxide
CO_2eq	CO_2 equivalent
EAS	East Asian Summit
ECTF	Energy Cooperation Task Force
EDI	Equally Distributed Index
EI	Education Index
EMP	Total Employment generated in Person days
EPH	Employment Generated per ha
ERIA	Economic Research Institute for ASEAN and East Asia
GDI	Gender-related Development Index
GDP	Gross Domestic Product
GE	Gross Enrolment
GEI	Gross Enrolment Index
GER	Gross Enrolment Ratio
GHG	Greenhouse Gas
GI	GDP Index
GNP	Gross National Product
GoI	Government of India
GVA	Gross Value Added
GWP	Global Warming Potential
ha	Hectare
HDI	Human Development Index
HDR	Human Development Report
IDR	Indonesian Rupiah
IEA	International Energy Agency
INR	Indian Rupee

IPCC	Intergovernmental Panel on Climate Change
ISO	International Organization for Standardization
LCA	Life Cycle Assessment
LC-GHG	Life Cycle Greenhouse Gases
LCI	Life Cycle Inventory
LCIA	Life Cycle Impact Assessment
LEI	Life Expectancy Index
LUC	Land Use Change
MPCE	Monthly per Capita Expenditure
NBL	Nandan Biomatrix Limited
Ncult	Number of persons employed in cultivation
NEcI	Normalized Economic Indicator
NEnI	Normalized Environmental Indicator
NH	Number of ha of the proposed plantation
Noilext	Number of persons employed in oil extraction
N_2O	Nitrous Oxide
NSoI	Normalized Social Indicator
NSS	National Sampling Survey
NWD	Number of working days in a year
PCI	Per Capita Income
PHP	Philippine Peso
PPP	Purchasing power parity
RBD	Refined, bleached deodorized
RTFO	Renewable Transport Fuel Obligation
SBTL	Southern Online Biotechnologies Limited
SDIs	Social Development Indicators
SSEV	Self Sufficient Energy Village
TBOs	Tree Borne Oils
THB	Thai Baht
TNP	Total Net Profit
TOIL	Tree Oils India Limited
TVA	Total Value Added
UNDP	United Nations Development Programme
USD	United States Dollar
VA[2]	Value-added
WG	Work Group

[2] "Value added" (VA) in this report is different from the definition of "Value Added" by the System of National Accounts (SNA). Please refer to Chapter 2.2 for the details.

Executive Summary

This report contains the outcome of four pilot scale projects on assessment of sustainability of biofuels in East Asia conducted in selected countries, viz. India, Indonesia, the Philippines and Thailand. Most of the countries in the East Asian region are heavily dependent on fossil fuel imports to meet their energy needs. This is not only increasing the financial burden on their national economy but also threatening their energy security. Governments in this region are looking for various energy alternatives and, in this regard, biomass energy, especially liquid biofuels such as bioethanol and biodiesel, have emerged on the forefront. Biofuels' blending with the fossil fuels would result in foreign exchange saving due to lesser imports of fossil fuels, may reduce greenhouse gas (GHG) emissions, and increase social benefits due to employment generation from biomass energy development. Thus, development of biomass energy could be a boon for the East Asian region. However, some negative impact of bioenergy development on biodiversity and food security cannot be ignored. Efforts are needed to ensure that development of bioenergy is sustainable in the long run.

The assessment methodology used in the pilot studies is based on the guidelines developed by an expert working group (WG) of ERIA. In addition, an integrated assessment and sustainability indicators are suggested, which integrate three indicators of environmental, economic and social assessments into a single indicator. This may facilitate decision-making as it is relatively straightforward to rank various options when each option has a single "sustainability value" attached to it. A visualization technique is presented wherein all three indicators are shown together in a single diagram.

Some major biomass feedstocks used for energy in the East Asian region include sugarcane, cassava, palm oil coconut oil and non-edible tree oils such as Jatropha seed oil. The choice of feedstock depends on its availability and cost for production of biofuels. The case studies involved primary data collection through field surveys of concerned stakeholders in each country. The results of sustainability assessment of biofuel production are expressed in terms of environmental, economic and social impacts and indicators used for these impacts were Greenhouse Gas Emissions (GHGs), total value added (TVA) and Human Development Index (HDI), respectively.

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. In biodiesel production stage, both TVA and net profit are quite attractive, provided the raw material is available at a reasonable price. During the lifecycle of biodiesel production process, a TVA of 522,569,245 INR and a net profit of 280,323,245 INR per year were estimated. On environmental fronts, 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 tonnes of CO_2eq per year. On social fronts, 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.

Biofuel 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 waste water treatment is flared or not. Economic assessment indicates that processing cassava for bioethanol increased the value added of cassava by about 950-1108 IDR per L of bioethanol or about 146.6-171 IDR per kg of cassava. On social assessment, the HDI values for cassava farmers in the study region were estimated lower than the HDI values for North Lampung, in general. In case of Jatropha biodiesel, farmers in Way Isem receive a very low benefit from cultivation stage, however, utilisation of Jatropha waste increased their earnings significantly. Environmental assessment indicates that GHG emissions from Jatropha plantation and Crude Jatropha Oil (CJO) processing were 59% and 82%, respectively. HDI and GDI estimates for Jatropha farmers in North Lampung indicate that life quality, education, and income for the people in Way Isem were quite low.

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 per kg) and lowest for CME production (at 0.122 PHP per L). The cumulative total profit for all product forms is about 38,000 PHP per ha and the Total Value Added from the biodiesel industry in the province of Quezon would be 13.74 billion PHP. The use of CME 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.

In 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 lower than 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 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.

It is concluded that the four pilot projects were implemented primarily to test the WG methodology, and findings of the studies using WG guidelines, in general, were satisfactory. However, some locale-specific modifications may be needed for future applications of the guidelines. The data collection exercise to calculate various indices was complex and time consuming and required personnel who are well–versed with the methodologies and the biomass industry.

The results of pilot studies indicate that indicators GHG savings as the environment indicator; net profit, TVA and forex savings as economic indicators; and change in HDI as the social indicator are appropriate and can be used for the East

Asian Region. For enhancing the application and output of the sustainability assessment methodology, it is recommended that clarity of goals and scope of study is pre-defined; Units and measurements are harmonised; Data collection procedures used should be standardised; Reporting format of the study results is uniform; and, international standards should be adopted. It is emphasized that utilisation of all by-products in the production of biomass energy is necessary to increase the sustainability of the biomass energy project.

Finally, it is suggested that the 'Guidelines for Sustainability Assessment of Biomass Utilisation' are robust enough for studies at community, regional and national levels and they may be applied to each country in the East Asian region with minor locale-specific modifications.

1. BACKGROUND AND CURRENT BIOFUEL SUSTAINABILITY ISSUES

ERIA WG on "Sustainability Assessment of Biomass Utilisation in East Asia" has been carrying out discussion on 'Sustainable Biomass Utilisation Vision in East Asia' (Sagisaka, 2008) since 2007. At the second East Asian Summit (EAS) in Cebu Island, of the Philippines, January 2007, East Asian leaders emphasised that East Asia should play a lead role in achieving energy security and mitigating climate change problems. Subsequently, Energy Ministers and Energy Cooperation Task Force (ECTF) in EAS countries, led by the governments of the Philippines and India, took initiative on development of "Biofuels for Transport and other Purposes". The WG activities have been oriented towards the objectives of the ECTF and contributing to its efforts.

The WG in its report suggested policy recommendations and framed "Asian Biomass Energy Principles," which were discussed at the EAS held at Bangkok, Thailand, in August 2008. These principles were endorsed by the Energy Ministers of the region and they requested ERIA to develop a methodology to assess the environmental, economic and social impacts of biomass utilisation for energy production by considering specific regional circumstances. In response to this request, the WG started investigations to develop 'Guidelines for Sustainability Assessment of Biomass Utilisation in East Asia' (ERIA, 2009).

Recent Biomass Issues in Selected EAS Countries

a) India

India has a large number of plant species yielding edible and non-edible oils. The Botanical Survey of India has identified 36 non-edible oil-yielding varieties of plants but most used plants for production of biofuels are *Jatropha curcas* and *Pongamia pinnata*. The estimated potential for tree borne oil seeds (TBOs) in India is 500,000 tonnes annually of which only about 10% is exploited, currently (MoA, 2006).

Biodiesel in India is produced by the transesterification of vegetable oils but since the demand for edible vegetable oil exceeds the supply, non-edible oils are being promoted as main feedstock. Although the demand for diesel is five times higher than the demand for petrol, in comparison to mature ethanol industry, the biodiesel industry is still at its early stage in India. Government of India (GoI) has formulated an ambitious National Biodiesel Mission (NBM) to meet 20% of the country's diesel requirements in near future.

Biodiesel policy of December 2009 announced by the Ministry of New and Renewable Energy, GoI, envisages 20% blending mandate by 2017. Corporates are encouraged to take up contract farming through minimum support price (MSP) mechanism. Biofuel plantations are encouraged in government/community wasteland, degraded or fallow land in forest and non forest areas – gives clarity on forest lands being used for biodiesel plantations. Employment provided in the plantations is being made eligible for coverage under the Mahatma Gandhi National Rural Employment Guarantee Programme (MNREGP). In addition, the entire biofuel processing infrastructure is categorised under the priority sector for facilitating easy availability of funds through lending by financial institutions and banks.

b) Indonesia

In order to reduce oil dependence, Indonesia has taken an important step to increase renewable energy contribution in the national energy supply by releasing

President's Regulation (Peraturan Presiden) No.5/2006 on the National Energy Policy. Based on the regulation, it is expected that by 2025 the share for oil should be reduced to 20% of the national energy consumption. At the same time, the share of biofuels should be increased to at least 5% in the national energy mix. According to the Blueprint of National Energy Management, bioethanol and biodiesel are the biofuels to be developed among other fuel types.

In response to the search for the sustainable energy sources as mentioned in the President's Instruction No. 1/2006, the local government of Lampung Province has recently initiated a program called Desa Mandiri Energy or Self Sufficient Energy Village (SSEV). In fact, several initiatives for biofuel development have been taken up by various stakeholders from private, non governmental organisation (NGO) and government, as well as from communities.

According to National Team for Biofuel Development (Tim Nasional Pengembangan BBN, 2006), Desa Mandiri Energy is designed to:

- Promote labour absorption, inclusion of the poor, and to satisfy local energy demand.
- Include poor fishermen villages, remote areas, and transmigration villages.
- Obtain support from institutions and cooperative units, as well as from small and medium scale entrepreneurs.
- Have additional support by local government, such as subsidy on seeds, seedlings, tools, or other facilities, shown in the approved local (province and district) budgets.

c) The Philippines

The Philippines is a major producer of coconut and as of 2008, about 3.38 million ha or 28% of total agricultural lands of the country are devoted to coconut. This provides livelihood to more than three million coconut farmers. On an average, the industry contributes to 5.97% of Gross Value Added (GVA) and 1.14% to Gross National Product (GNP), annually. Coconut industry dominates the Philippines' agriculture sector and it is one of the major foreign exchange earning sectors of the country. According to the Department of Agriculture (DA) annual average forex earning from coconut industry is about 800 million USD or 40 billion PHP. Among the coconut producing provinces in the country, Quezon has the largest volume of production, accounting for almost 9%, each year, to overall national production (based on the data by the Bureau of Agricultural Statistics). Moreover, Quezon had the biggest land area in coconut production contributing to about 7.4% to the country's total harvest.

d) Thailand

Thai government is pushing forward an alternative energy plan called "15-Year Renewable Energy Development Plan" (2008 - 2022), which is divided into three parts; short term, medium term, and long term. The short term plan (2008-2011) is focusing on promoting the proven alternative energy technologies with high potential sources such as biofuels, heat and power generation from biomass and biogas where the financial support measures will be fully implemented. The medium term plan (2012-2016) is to promote the alternative energy technology and support the development of new prototype of alternative energy technology with higher cost-efficiency. This includes promoting new technologies for biofuel production. The long term plan (2017-2022) is to promote new technologies of alternative energy, which are cost-effective and to export the alternative energy and technology as a hub of biofuel export in the ASEAN region. Details of these plans are shown in Table 1-1.

Table 1-1 Goals of 15-year Renewable Energy Development Plan (2008-2022)

Energy Type	Potential	Existing	2008-2011	2012-2016	2017-2022
Electricity from biomass (MW)	4,400	1,597	2,800	3,235	3,700
Electricity from biogas (MW)	190	29	60	90	120
Electricity from MSW (MW)	320	5	100	130	160
Heat from biomass (kTOE)	7,400	2,340	3,544	4,915	6,725
Heat from biogas (kTOE)	600	79	470	540	600
Heat from MSW (kTOE)	78	1	16	25	35
Ethanol (ML/day)	3.3	1	3	6.2	9
Biodiesel (ML/day)	3.3	1.39	3	3.64	4.5

Source: Minister of Energy, Thailand

According to Ministry of Energy, Thailand (2009), Thai government has been encouraging the production of biofuel and the utilisation of biomass such as the productions of gasohol (E10, E20 and E85) and biodiesel (B5), and the utilisation of solid wastes and agricultural residues through the implementation of the energy plan, aiming to achieve the target by the year 2022.

2. ASSESSMENT METHODOLOGY FOR BIOMASS SUSTAINABILITY

The purpose of this study was to assess the sustainability of biofuel production from utilisation of various feedstocks in Indonesia, the Philippines, India, and Thailand. The 'Guidelines to Assess Sustainability of Biomass Utilisation in East Asia', developed by ERIA Working Group on "Sustainability Assessment of Biomass Utilisation in East Asia" (ERIA, 2009), were used as the method of assessment. The study teams in each country investigated the sustainability of various feedstocks' utilisation for bioenergy from environmental, economic and social aspects.

This chapter explains the methodology of estimating three indicators of sustainability, involving environmental, economic and social aspects, which are applied to four pilot studies, one in each of the four countries. Since this methodology was developed in the preceding project, the report 'Guidelines to Assess Sustainability of Biomass Utilisation in East Asia' may be referred for more details.

All four pilot studies were quite different in terms of feedstock of biofuel, types of final products and by-products and the scale and complexity of biofuel production systems. It was difficult to simply apply the same procedures and equations necessary for each indicator to all the four pilot studies. Hence, this chapter explains (1) the minimum steps required for data collections and calculations of GHG savings in the environmental aspect, (2) the necessary equations and calculations for TVA taking Philippines' pilot studies as an example in the economic aspect and (3) the way of how to calculate HDI and other SDIs with an example of Indian pilot study.

2.1. Indices for Environmental Assessment

The Life Cycle Green House Gases (LC-GHG) emissions, sometimes referred to as carbon footprint or carbon intensity, are taken up as an indicator of environmental impact assessment. A brief explanation of estimating this indicator in the four pilot studies is given below.

In each pilot study, the LC-GHG emissions are estimated throughout the lifecycle of biofuel production, which usually covers feedstock production, feedstock processing, production of final product and all the associated processes. As an example, the lifecycle of biofuel production consists of nursery for seedlings, cultivations of crops, transportations of biomass, processing of harvested crops, production of biofuels, waste treatments, etc. However, emissions associated with manufacturing of machines and vehicles, constructing irrigation structures, buildings, infrastructures, etc. as well as manual labour for new planting, pruning, harvesting, machine operating, driving, etc, were not considered.

The assessments for LC-GHG emissions are conducted based on the Life Cycle Assessment (LCA) standardised in ISO14040s (hereinafter referred to as ISO-LCA). To estimate LC-GHG emissions, all of the pilot studies followed the main steps of ISO-LCA, i.e. 1) goal and scope definition, 2) life cycle inventory (LCI) analysis, 3) life cycle impact assessment (LCIA) and 4) interpretation.

Each step of ISO-LCA used in the pilot studies is described as follows.

2.1.1. Definition of Goal and Scope

Since the indicator for an environmental aspect chosen here is LC-GHG emissions, the principal goal of the pilot studies is to analyse environmental sustainability in terms of GHG emissions, in other words, whether the GHG emissions of biofuel are smaller than those of the fossil fuel replaced by the biofuel. This may be tested by calculating GHG savings, which are the difference in GHG emissions between biofuel and fossil fuel. Since there are two kinds of biofuel taken into consideration in the pilot studies, GHG savings were estimated as the difference in GHG emissions either between bioethanol and gasoline, or between biodiesel and conventional diesel.

The system boundary and the functional unit are set in accordance with the elements necessary for estimating GHG savings. The types of GHG taken into account in the pilot studies are CO_2, CH_4, and N_2O. CO_2 is, for example, released from combustion of fossil fuels and some chemical reactions, CH_4 from biomass combustion and waste treatments, and N_2O from fertilizer applications.

It should be noted that CO_2 emissions from the combustion of biomass-derived fuels or materials such as biofuels, bagasse, rice and coconut husks, etc. are not counted in the pilot studies according to the carbon neutral concept which assumes that the carbon emissions in biomass combustion are offset by the carbon absorbed via photosynthesis during biomass growth.

The issues and additional necessary data found during the implementation of LCA in the pilot studies (e.g., GHG emissions of fossil fuels compared with biofuel, allocation methods and land use change) are discussed in Chapter 4.1.

2.1.2. Life Cycle Inventory (LCI) Analysis

In this step, all the data necessary for estimating GHG emissions are collected and analysed throughout the lifecycle of biofuel, and ultimately classified as the quantities of each type of GHG released into the air.

The data collected are divided into two types; primary and secondary data. The primary data in the pilot studies are mainly collected from field surveys using the questionnaire developed in the WG guidelines or by directly asking farmers, companies and other stakeholders. The secondary data are some information retrieved from other sources such as literatures, LCI database, etc. because some activities are operated outside the sites where field work is done. For example, among the primary data are the types and quantities of electricity consumed in the biofuel productions, whereas the secondary data are the raw material or fuels consumed for generating electricity in power plants far away from the site of biofuel production, which were obtained from literature. In the cases where the primary and secondary data for a process or product are not available and their amounts are estimated to be lesser than 1% in weight, they were treated as negligible.

The data collected are carefully checked and converted into the quantities of three types of GHG released into the air, i.e. CO_2, CH_4 and N_2O.

2.1.3. Life Cycle Impact Assessment (LCIA)

There are five steps in LCIA of the ISO-LCA; classification, characterization, normalization, grouping and weighting. The pilot studies take the first two steps of classification and characterization that are the mandatory elements of LCIA according to the provision of ISO-LCA. The steps of normalization, grouping, and weighting that are the optional elements are not taken up in the pilot studies due to the main scope of project objectives.

Since the pilot studies focus on one impact category, i.e., global warming, the classification was self-evident in LCI. In other words, it is clear that three kinds of GHG emissions in the LCI results belong to the impact category of global warming.

Then in the step of characterization, three kinds of GHG emissions are aggregated in the unit of 'kg-CO_2 equivalent' by the following equation.

$$\text{Global Warming Impact (GHG emissions) [kg-CO}_2\text{eq]} = \sum_i Q_i \times GWP_i$$

where Q_i is the emissions and GWP_i the global warming potential of green house gas i, respectively. GWP represents an indicator for the ability of green house gas relative to that of CO_2 to trap heat in the atmosphere.

The Intergovernmental Panel on Climate Change (IPCC) provides several versions of GWP depending the published years and the time span. To reflect the newest scientific knowledge in the studies, GWP data over 100 years in the fourth assessment report of IPCC (2007) are used in all of the pilot studies.

2.1.4. Interpretation

The objective of this step is to analyse results, draw conclusions, explain limitations and provide recommendations. In the pilot studies, the following issues were discussed and analysed.

- Whether or not GHG savings are positive (Whether biofuel contributes to the reduction of GHG emissions).

- Main sources of emissions from each lifecycle stage.

The methods and assumptions used in the pilot studies as well as the results of GHG emissions and savings were reviewed in the working group and then revised, if required. The results of each pilot study are summarised in the next chapter.

2.2. Indices for Economic Assessment

The economic indicators for calculating the economic impact in the pilot studies are the following: a) total net profit (TNP) accumulated from product conversion or processing; b) employment created from the biomass industry; c) tax revenues generated from the different entities within the industries; and d) foreign trade impacts in terms of foreign exchange earnings and savings.

2.2.1. Total Net Profit

Costs and Benefits (monetary returns) Analysis was used to determine the net profit of the key enterprises in biofuel industry. To determine the profitability, total production costs were deducted from the returns gained from the enterprise. Returns in the enterprise include revenue from sales of the primary output and sales from by-products. Total costs, on the other hand, include value of all inputs supplies used in the production process, such as purchasing costs of biomass, cost of its processing, costs of electricity and chemicals other inputs. In addition to the value of intermediate inputs, labour costs including wages and salaries, as well as the various taxes and duties charged in the production process, and other costs items are also included. To determine the profit, the following formulae were used:

Total Returns = Sales from Primary Output + Sales from By-products

Total Costs = Value of Material Inputs Used + Labour Costs + Overhead Costs

Overhead Costs = Taxes and Duties + Interest + Depreciation

Net Profit = Total Returns – Total Costs

Total net profit (TNP) is the sum of the net profit generated from both the main product and the by-products.

The calculation for the total cost is divided into three stages. First stage is the *Production*. This stage accounts for the costs incurred in the actual production process of the raw material or initial product. This involves the farming costs. For example, in case of coconut, *production* stage corresponds to mature nut production which is the initial product for biomass processing.

Second stage is the *Primary Processing* where the raw material or initial product undergoes processing up to the point in which the output is already a convertible material for biofuel production. This involves the extraction costs. For example, *Primary Processing* for coconut involves copra and refined oil production. Mature coconut serves as the input in copra processing.

Third stage is the *Secondary Processing.* From the readily convertible material in the second stage, certain processes such as esterification are undertaken to produce the final product which is biofuel. This involves the biodiesel production costs. A readily convertible material for biomass production such as refined oil undergoes *Secondary Processing*, specifically the process of esterification, to arrive at the final product which is biodiesel.

2.2.2. Employment Generation and Personnel Remuneration

Employment impact is the number of jobs that can be generated with the presence of the energy project which is computed as follows:

Employment = Total Production × Labour Requirement for every unit produced

If labour requirement is in terms of man-days, necessary conversion will be done such that the computed value could be translated into number of jobs created to provide a more concrete view of the employment impact of biomass production and processing.

The extent of the economic impact with the presence of the biomass industry can be measured through the number of jobs that can be hired by the industry. To estimate this, the total number of man-days required for each stage all throughout the production process was computed. The value is then translated in terms of the number of labourers employed.

Employment = Total Production of Biomass or Biofuels × Labour Requirement per Unit of Biomass or Biofuels Produced

Personnel remuneration on the other hand refers to the total salaries and wages paid to the employees in the different firms or activities involved in the biomass utilisation. This is computed as:

Personnel Remuneration = Total Man-days × Average Wage per Man-day

2.2.3. Tax Revenue

Tax revenue is the income generated by the government from the entities involved in each production process. This is computed as follows:

Tax = Total Taxable Income × Tax Rate; where,

Total Taxable Income

= Income from main product (Profit per unit of product A × Volume of A)

+ Income from by-product (Profit per unit of by-product B × Volume of B)

For example, taxes generated from the coconut industry can be obtained by multiplying the prevailing tax rate by the total taxable income of each sector (i.e. copra, unrefined oil, and CME producers). However, coconut farmers are exempted from paying taxes as stipulated under the Comprehensive Agrarian Reform Program of the Philippines. Thus, no taxes are generated from the farming sector.

Tax = Total Taxable Income from copra, unrefined oil, and coconut methyl ester production × Tax Rate

2.2.4. Foreign Trade

Foreign trade impact is determined by two factors, (i) dollar earnings from product export and, (ii) dollar savings from reduced diesel imports with the presence of the energy project. The computations for each are as follows:

Dollar Earnings = Price per unit of convertible material × Total volume of exports

Dollar Savings = Amount (in weight) of biomass × Density × Forex savings per unit of fossil fuel replaced

In the event that portions of the convertible material are both exported and consumed locally for biodiesel production, a trade-off occurs. Dollar earnings from exports will then be reduced with domestic consumption. The net effect of this trade-off can be computed as follows:

Net Effect = Reduced Dollar Earnings + Dollar Savings

For example, in case of the Philippines, coconut oil is one of the top dollar earners of the country and represents the Dollar earnings for the coconut industry. With the adoption of CME, a portion of the total volume of production of unrefined oil will be dedicated to CME production. As a result, the volume of exports is reduced and, hence, dollar earnings are reduced. On the contrary, dollar savings arises from CME adoption in lieu of diesel imports. Thus, a trade-off occurs. The net effect of this trade-off can be quantified by adding the reduced dollar earnings from unrefined oil exports and the dollar savings from displaced diesel by CME.

Reduced Dollar Earnings = (Price per unit of coconut oil exports × Total volume of exports) x % to be used for CME production

Dollar Savings = [(Tonne of unrefined oil produced x % to be used for local consumption)/Density (kg/L)] × Forex savings per L of displaced fossil diesel by CME[3]

[3] A constant estimated by the Department of Energy, the Philippines.

Net Effect = (Reduced Dollar earnings from unrefined oil exports)

+ Dollar savings from reduced diesel imports

2.2.5. Total Value Added

The TVA for the industry included the summation of all the value-added in each enterprise, which include personnel remuneration, taxes and duties earned by the government from the enterprises and the entrepreneur's net profit. Thus, total value added for the industry is given by the formula:

Total Value Added

= Total Net Profit + Personnel Remuneration + Tax Generated

Other benefit for the economy includes the foreign exchange earnings from exported products.

2.3. Indices for Social Assessment

For sustainability of biofuels, assessment of their social impacts is as important as environmental and economic impacts. It is necessary that the cultivation of biofuel crops such as Jatropha and other oil trees, sugarcane, coconut, etc, is socially acceptable. This can only happen when farmers are convinced that their involvement in plantation of biofuel crops and other stages of biofuel production will economically benefit them and improve their standard of living.

At global level, the social development is measured by the Human Development Index (HDI) developed by the UNDP. However, there is a general lack of data and information on estimation of the social impact of bioenergy, especially in terms of the HDI. Such estimation requires compressive data set for the region where biofuel crops cultivation has been taken up. The data should contain farm level information on production of biofuel crops and information throughout the value added chain during the lifecycle of biofuel production. Some of the problems with the data and information available and assumptions made in estimation of HDI are stated as follows.

For calculating the social impact of biofuel crops cultivation, in most cases, the data are available for income generation only. But subsequent relationship between income and life expectancy, education, etc. is required, which is not available at micro level. However, this information is available at macro level, which has been used for micro level estimations. For calculating Gender-related Development Index (GDI), data about political and social status of women is required. There is no data available that can give political or social status of women with biofuel crops' intervention.

Therefore, in addition to calculating the change in the HDI, it was considered that some other social development indicators (SDIs) at micro level should be estimated. GDP per capita, Education and Health aspects may be captured through social parameters such as Employment, Life Expectancy, etc. Some other SDIs to see the condition of women, socially deprived groups, etc, give an overall assessment of social development. However, it is to be noted that estimation of SDIs have many issues, which at micro or macro level may give biased results. Also, other SDIs may not be comparable at international level as the same SDI may carry different meaning in various countries. For example, National Sampling Survey (NSS) of India categorizes households into various classes based on monthly per capita expenditure (MPCE). The standard of living is considered higher among the number of households per 100 households that fall in a particular category of MPCE. If this number of households has three amenities, viz., water, latrine and electricity within their premises, it is considered a higher standard of living. However, similar definition of living standard may not be true in case of other East Asian countries, for example in Japan and Singapore.

The methodologies for calculation of HDI for all country case studies and other SDIs (with an example of India case study) are described as follows.

2.3.1. Estimation of HDI

HDI measures three social factors, namely, life expectancy at birth, as an index of population, health and longevity; adult literacy rate (with two-thirds weighting) and the combined primary, secondary, and tertiary gross enrolment ratio (with one-third weighting); and the gross domestic product (GDP) per capita at purchasing power parity (PPP) in USD. These three factors, expressed as respective three sub-indices in HDI. Since values measuring these social factors have different units, it is necessary to standardise them, which allows them to be added together. In general, to transform a raw variable, say *x*, into a unit-free index between 0 and 1, the following formula is used:

$$\text{x- index} = \frac{x - \min(x)}{\max(x) - \min(x)}$$

where, min (*x*) and max (*x*) are the lowest and highest values that variable *x* can attain, respectively. The Maximum or Minimum values, which these variables can take, known as goalposts in UNDP terms, are given in Table 2-1.

Table 2-1 Goalposts used in UNDP method of HDI

Index	Measure	Minimum value	Maximum value
Longevity	Life expectancy at birth (LE)	25 yrs	85 yrs
Education	Combined gross enrolment ratio (CGER)	0%	100%
GDP	GDP per capita (PPP)	100 USD	40,000 USD

Source: ***UNDP***

The three sub-indices of HDI and their equations are defined as follows.

2.3.1.1. Life Expectancy Index

Life expectancy is the average expected lifespan of an individual. In countries with high infant mortality rates, the life expectancy at birth is highly sensitive to the rate of death in the first few years of life. In such cases, another measure such as life expectancy at age one can be used to exclude the effects of infant mortality and reveal the effects of causes of death other than early childhood causes. Quantified life expectancy, often called Life Expectancy Index (LEI), measures the relative achievement of a country in life expectancy at birth.

$$\text{Life Expectancy Index} = \frac{LE-25}{85-25}$$

2.3.1.2. Education Index

The Education Index (EI) comprises of *Adult Literacy Index* (ALI) and *Gross Enrolment Index* (GEI). The EI is measured by the adult literacy rate (with two-thirds weighting) and the combined primary, secondary, and tertiary gross enrolment (GE) ratio (with one-third weighting). The adult literacy rate gives an indication of the ability to read and write, while the GE ratio gives an indication of the level of education from kindergarten to postgraduate education.

Education Index = (2/3) × ALI + (1/3) × GEI

where,

Adult Literacy Index (ALI) = $\frac{ALR - 0}{100 - 0}$

and,

Gross Enrolment Index (GEI) = $\frac{CGER - 0}{100 - 0}$

2.3.1.3. GDP Index

GDP Index (GI) is calculated using adjusted GDP per capita in USD. Income is adjusted because achieving a respectable level of human development doesn't require unlimited income. It is measured by the natural logarithm of gross domestic product (GDP) per capita at purchasing power parity (PPP) in USD.

GDP Index = $\frac{\log(GDPpc) - \log(100)}{\log(40000) - \log(100)}$

Finally, the HDI is calculated by taking a simple average of above three indicators:

HDI = 1/3 (Life Expectancy Index + Education Index + GDP Index)

The steps used to calculate the HDI at micro level in Indian case study are mentioned below.

Step 1: Estimate the direct employment from Jatropha cultivation that includes persons employed in site preparation, Jatropha plantation and post plantation work. This direct employment in person days per ha is calculated for consecutive 5 years.

Step 2: Estimate the indirect employment from Jatropha cultivation and biodiesel production that includes employment in post harvest activities such as seed collection, oil extraction, transportation and other related activities. It is also calculated in person days per ha of Jatropha crop.

Step 3: Aggregating the cost of direct and indirect employment per ha of Jatropha plantation, which is multiplication of person days of employment created and salary per person at the location.

Step 4: For calculating GDP (PPP) per capita, data from step 3 (say, X INR/ ha of Jatropha) are used to calculate total income generated from Z ha of land. Therefore, XZ INR is divided by total population of the area and added to the original GDP of place which gives GDP per capita, which can be converted into USD i.e. GDP in terms of purchasing power parity (PPP) as per UNDP method.

Step 5: The HDI can be calculated by given formula HDI = 1/3(LEI+EI+GI) as earlier.

Where,

LEI: Life Expectancy Index; Life expectancy data was taken from the area.

EI: Education Index; EI = (2/3) ALI + (1/3) GEI

ALI: Adult Literacy Index; data taken from area.

GEI: Gross Enrolment Index; data taken from area.

GI: GDP index (USD) will be given by

$$GDP\ Index\ (GI) = \frac{Log(actua\,value) - Log(100)}{Log(40000) - Log(100)}$$

where actual values are taken from Step 4 above.

Step 6: The change in HDI is calculated by subtracting HDI at the local site and the HDI for India for that particular year.

2.3.2. Stepwise Estimation of HDI

Stepwise estimation of impact on various sub-indices of HDI during various stages of biofuel production is calculated as follows.

Step 1: Estimate the employment generated in person days through biofuel plantation of one hectare, during various stages.

(EPH) cult = Employment generated per ha during cultivation stage

(EPH) oilext = Employment generated per ha during oil extraction stage

(EPH) trans = Employment generated per ha during transesterification stage

Step 2: Assuming a certain number of working days per year, estimate the total number of persons employed throughout the year with one ha of plantation during each stage.

Ncult = (EPH) cult / NWD

Noilext = (EPH) oilext / NWD

Ntrans = (EPH) trans / NWD

where,

Ncult = Number of persons employed in cultivation

NWD = Number of working days in a year

Noilext = Number of persons employed in oil extraction

Ntrans = Number of persons employed in transesterification

Step 3: Estimate the monthly per capita income generated based on the number of working days per month and the minimum wage rate.

Δ MI = Increase in the monthly per capita income generated

Step 4: From the secondary country specific data (for example, NSS data for Indian pilot study), estimate the rise in literacy level (per 1000 persons) on account of increase in per capita income.

Δ LL = Rise in literacy level per 1000

Step 5: Estimate the increase in literacy (□LIT), during each stage, on account of the one ha of plantation.

$\Delta LITcult = (\Delta LL \times Ncult) / 1000$

$\Delta LIToilext = (\Delta LL \times Noilext) / 1000$

$\Delta LITtrans = (\Delta LL \times Ntrans) / 1000$

Step 6: The overall increase in the literacy levels per hectare of plantation is given by:

$\Delta LIT = \Delta LIT\ (cult + oilext + Trans)$

2.3.3. Gender-related Development Index (GDI)

The Gender-related Development Index (GDI) is calculated to reflect inequalities between men and women in all the three dimensions used in calculating HDI. The three sub-indices, i.e., life expectancy index, education index and GDP index are calculated separately for men and women, as suggested in step 5 of sub-section "estimation for HDI" and an equally distributed index is calculated for each dimension. First, share of men and women is calculated by dividing women population by total population and the same is done for the men. It is to be noted that, as per UNDP's goal posts for GDI, maximum and minimum values of life expectancy for women are 87.5 and 27.5 and for men are 82.5 and 22.5, respectively.

Then, the GDI is calculated by taking the average of equally distributed index of all three indices as discussed above. GDI values are presented as percentage of HDI.

Step 1: Unit free indices between 0 and 1 are calculated for females and males in each of the following areas- Life Expectancy, Education and Income.

Life Expectancy Index of Gender

= (Life Expectancy of Gender – min (Life Expectancy of Gender))

/(max(Life Expectancy of Gender)- min (Life Expectancy of Gender))

Adult Literacy of Gender

= (Adult Literacy of Gender – min (Adult Literacy of Gender))

/(max(Adult Literacy of Gender)- min (Adult Literacy of Gender))

Income Index of gender

$$= \frac{log(\text{earned income of gender}) - log(100)}{log(40,000) - log(100)}$$

Step 2: For each area, the pair of gender indices are combined into an Equally Distributed Index that rewards gender equality and penalizes inequality. It is the harmonic mean of two gender specific indices.

$$\text{Equally Distributed Index} = \frac{\log(\textit{earned income of gender}) - \log(100)}{\log(40{,}000) - \log(100)}$$

Step 3: The GDI is the average of the three Equally Distributed Indices viz. Equally Distributed Life Expectancy Index, Equally Distributed Education Index and Equally Distributed Income Index.

2.3.4. Estimation of Some Other SDIs

In addition to HDI and GDI, some other SDIs were also estimated in all pilot studies. However, as mentioned earlier, due to difference in social set of each pilot study country, the same SDI may have different meaning or measure of social assessment. But in most cases, changes in SDIs are related to income of individuals. For example, the Indian pilot study uses relationship of SDIs with National Sampling Survey of India (NSS) data. The NSS has categorises households in rural India in terms of monthly per capita expenditure (MPCE) and its effect on various social development indicators (SDIs). The impact on these SDIs with rise in MPCE is described as follows.

2.3.5 Impact on Literacy

The literacy levels (per 1000) across the Monthly per Capita Expenditure (MPCE) classes in the rural India, as per the NSS Report 2004-05, are as in Table 2-2. Due to rise in income and expenditure, the number of households falling under a particular MPCE class will change, which can be found from Table 2-2.

Step 1: Estimate the employment generated in person days with a biofuel plantation of one hectare.

EPH = Employment Generated per ha

Step 2: Estimate the total employment generated in person days by the proposed plantation as mentioned above.

$$EMP = EPH \times NH$$

where,

EMP = Total employment generated in person days

NH = Number of ha of the proposed plantation

Table 2-2 MPCE class and literacy levels

MPCE Class	Number per 1000 households with no literate person above 15 years in all members
less than 235	444
235 -270	436
270 -320	382
320 – 365	352
365 – 410	306
410 – 455	292
455 – 510	271
510 - 580	243
580 – 690	209
690 – 890	186
890 -1155	141
1155 & above	88
all classes	261

Source: NSS Report

Step 3: Assuming a certain number of working days per year, estimate the total number of persons employed throughout the year with the proposed plantation.

N = EMP/ NWD

where,

N = Number of persons employed

NWD = Number of working days in a year

Step 4: Estimate the monthly per capita income generated based on the number of working days per month and the minimum wage rate.

Δ MI = Increase in the monthly per capita income generated

Step 5: From the NSS data, estimate the rise in literacy level (per 1000 households) on account of increase in per capita income.

Δ LL = Rise in female literacy level per 1000

Step 6: Estimate the increase in literacy on account of the proposed plantation as mentioned above.

$\Delta LIT = (\Delta LL \times N) / 1000$

2.3.6. Impact on Female Literacy

The steps followed for total employees are now considered for female employees only and the employment of females generated is estimated following steps 1 to 6 to get employment of females in person days per ha of cultivation. The female literacy levels (per 1000) across the Monthly per Capita Expenditure (MPCE) classes in the rural India, as per the NSS Report 2004-05 are as in Table 2-3.

Table 2-3 MPCE class and female literacy levels

MPCE Class	Number per 1000 households with no literate person above 15 years in female members
less than 235	644
235 -270	711
270 -320	681
320 – 365	632
365 – 410	583
410 – 455	574
455 – 510	543
510 - 580	496
580 – 690	436
690 – 890	385
890 -1155	302
1155 & above	182
all classes	500

Source: NSS Report

2.3.7. Impact on Type of Dwelling

Step 1: Estimate the employment generated in person days with a plantation of 1 ha.

EPH = Employment Generated per ha

Step 2: Estimate the total employment generated in person days by the proposed plantation across India as mentioned above.

EMP = EPH × NH

where

EMP = Total employment generated in person days

NH = Number of ha of the proposed plantation

Step 3: Assuming a certain number of working days per year, estimate the total number of persons employed throughout the year with the proposed plantation.

$$N = EMP/ NWD,$$

where N = Number of persons employed and NWD = Number of working days in a year.

Step 4: Estimate the monthly per capita income generated based on the number of working days per month and the minimum wage rate.

Δ MI = Increase in the monthly per capita income generated

Step 5: From the NSS data, estimate the rise in the persons (per 100 persons) staying in the type of dwelling units on account of increase in per capita income.

Δ DW = Rise in persons staying in a type of dwelling per 100

Step 6: Estimate the increase in the persons staying in a type of dwelling unit on account of the proposed plantation, as mentioned above.

$$\Delta DWT = (\Delta DW \times N)/ 1000$$

Table 2-4 MPCE class and details of dwelling units

MPCE (INR)	Pucca	Katcha
0 – 225	22	33
225 – 255	23	32
255 – 300	25	28
300 – 340	26	29
340 – 380	29	25
380 – 420	31	23
420 – 470	35	22
470 – 525	38	18
525 – 615	42	17
615 – 775	48	13
775 – 950	53	9
950 or more	64	5
not reported	35	28
all classes	21	67

Source: NSS Report

As per NSS reports, the persons staying in type of dwelling unit (per 100) across the Monthly per Capita Expenditure (MPCE) classes in the rural India, as per the NSS Report 2002 are as in Table 2-4.

Due to income from Jatropha biodiesel production, there is an expected rise in income and expenditure, the number of person falling in a particular MPCE class can be calculated and change in dwelling units could be estimated.

2.3.8. Impact on Standard of Living

As per NSS norms the standard of living is estimated by finding out the rise in the persons (per 100 persons) staying in the dwelling units, where they have access to three basic amenities, viz., drinking water, electricity and latrine within the premises.

If there is change in this value on account of increase in per capita income, it is considered that living standard is improving.

Step 1: Estimate the employment generated in person days with a plantation of 1 ha.

EPH = Employment Generated per ha

Step 2: Estimate the total employment generated in person days by the proposed plantation across India as mentioned above.

$$EMP = EPH \times NH$$

where, EMP = Total employment generated in person days

NH = Number of ha of the proposed plantation

Step 3: Assuming a certain number of working days per year, estimate the total number of persons employed throughout the year with the proposed plantation.

$$N = EMP / NWD$$

where, N = Number of persons employed

NWD = Number of working days in a year

Step 4: Estimate the monthly per capita income generated based on the number of working days per month and the minimum wage rate.

Δ MI = Increase in the monthly per capita income generated

Step 5: From the NSS data, estimate the rise in the persons (per 100 persons) staying in the dwelling units, where they have all the three amenities such as drinking water, electricity and latrine within the premises, on account of increase in per capita income.

ΔS = Rise in persons staying in a dwelling having all the three amenities per 100

Step 6: Estimate the increase in the persons staying in dwelling having all the three amenities on account of the proposed plantation across India as mentioned above.

$$\Delta SLT = (\Delta SL \times N)/ 1000$$

As per NSS reports, the persons staying in a dwelling unit with all three amenities (per 100) across the Monthly per Capita Expenditure (MPCE) classes in the rural India, as per the NSS Report 2002 are as in Table 2-5.

Table 2-5 MPCE class and details of standard of living

MPCE Class	Houses with all 3 amenities	Houses with none of the above amenities
0 – 225	3	52
225 – 255	1	49
255 – 300	2	44
300 – 340	3	41
340 – 380	5	35
380 – 420	5	33
420 – 470	8	28
470 – 525	8	24
525 – 615	15	21
615 -775	19	14
775 -950	27	11
950 or more	43	7
not reported	11	36
all classes	11	30

Source: *NSS Report*

Due to income from Jatropha biodiesel production, there is an expected rise in income and expenditure, the number of person falling in a particular MPCE class can be calculated and change in living standards based on three amenities in their dwelling units could be estimated.

2.3.9. Local Sub-Indices of HDI

Since data on literacy and life expectancy at local level are not available an alternative method for assessment of HDI is proposed here. For each country, the rise in per capita income and its relationship with change in literacy and life expectancy is available either at state level or province level or district level. For example in India, National Sampling Survey (NSS), data provide such kind of relationship at state level.

2.3.9.1. Life Expectancy Index

The increase in life expectancy is estimated as mentioned above, As shown in Table 2-6, which gives the state-wise life expectancy, a regression model is used to find the change in life expectancy due to rise in PCI.

Table 2-6 State-wise life expectancy and per capita income

State/UT	Population 2006	Life Expectancy (in years)	Per Capita Income (INR)
Andhra Pradesh	75730000	62.8	16373
Assam	26640000	59	10467
Bihar	82890000	65.7	5108
Gujarat	50600000	63.1	19228
Haryana	21080000	64.6	23742
Karnataka	52740000	62.4	18041
Kerala	31890000	71.7	19463
Madhya Pradesh	60380000	59.2	10803
Maharashtra	96750000	66.8	23726
Orissa	36710000	60.1	8547
Punjab	24290000	69.8	25048
Rajasthan	56470000	62.2	11986
Tamil Nadu	62110000	67	19889
Uttar Pradesh	166060000	63.5	9721
West Bengal	80220000	66.1	16072

Source: ://www. indiastat. com

Based on the data available for LE at the state-level, we can calculate the rise in LE due to rise in PCI as follows.

LE = 62.8 × (PCI at State Level+ Rise in PCI)/ PCI at State Level

where,

LE = Life Expectancy and

PCI = Per Capita Income

2.3.9.2. Adult Literacy Rate

The increase in Adult Literacy Rate s estimated as mentioned above. As shown in Table 2-7, which gives the state-wise ALR, a regression model is used to find the change in ALR due to rise in per Capita Income (PCI).

Table 2-7 States-wise adult literacy rates and per capita income

State/UT	Population	Adult Literacy Rate	Per Capita Income (INR)
Andhra Pradesh	75730000	44.87	16373
Assam	26640000	69.18	10467
Bihar	82890000	36.81	5108
Gujarat	50600000	61.04	19228
Haryana	21080000	57.82	23742
Karnataka	52740000	52.54	18041
Kerala	31890000	89.47	19463
Madhya Pradesh	60380000	47.52	10803
Maharashtra	96750000	66.82	23726
Orissa	36710000	51.35	8547
Punjab	24290000	62.59	25048
Rajasthan	56470000	42.1	11986
Tamil Nadu	62110000	61.67	19889
Uttar Pradesh	166060000	44.52	9721
West Bengal	80220000	62.46	16072

Source: ://www. indiastat. com

Based on the data available for ALR at the state-level, we can calculate the rise in ALR due to rise in PCI as follows.

$$ALR = 44.87 \times (\text{PCI at State Level} + \text{Rise in PCI}) / \text{PCI at State Level}$$

where,

ALR = Adult Literacy Rate and

PCI = Per Capita Income

2.3.9.3. Gross Enrolment Ratio

The increase in Gross Enrolment Ratio is estimated as mentioned above. As shown in Table 2-8, which gives the state-wise gross enrolment ratio, a regression model is used to find change in GER due to rise in per Capita Income (PCI).

Table 2-8 State-wise gross enrolment ratio and per capita income

State/UT	Population	Gross Enrolment Ratio	Per Capita Income (INR)
Andhra Pradesh	75730000	53.09	16373
Assam	26640000	49.41	10467
Bihar	82890000	22.47	5108
Gujarat	50600000	55.3	19228
Haryana	21080000	52.94	23742
Karnataka	52740000	59.03	18041
Kerala	31890000	93.19	19463
Madhya Pradesh	60380000	45.66	10803
Maharashtra	96750000	68.91	23726
Orissa	36710000	53.73	8547
Punjab	24290000	51.47	25048
Rajasthan	56470000	43.91	11986
Tamil Nadu	62110000	80.66	19889
Uttar Pradesh	166060000	48.92	9721
West Bengal	80220000	41.46	16072

Source: ://www. indiastat. com

Based on the data available for GER at the state-level, we can calculate the rise in GER due to rise in PCI as follows.

$$GER = 53.09 \times (\text{PCI at State Level} + \text{Rise in PCI}) / \text{PCI at State Level}$$

where,

GER = Gross Enrolment Ratio, and

PCI = Per Capita Income

3. RESULTS OF TESTING WG METHODOLOGY

3.1. Location of Pilot Studies

Four pilot studies that were implemented by designated organisations under the ERIA's framework to apply and test the assessment methodology developed by the WG in 2008. The WG suggested recommendations based on the results obtained from these pilot studies conducted in East Asian countries. One case study was implemented in each country, viz., India (Andhra Pradesh), Indonesia (Lampung), the Philippines (Quezon) and Thailand (Khon Kaen), as shown in Figure 3-1.

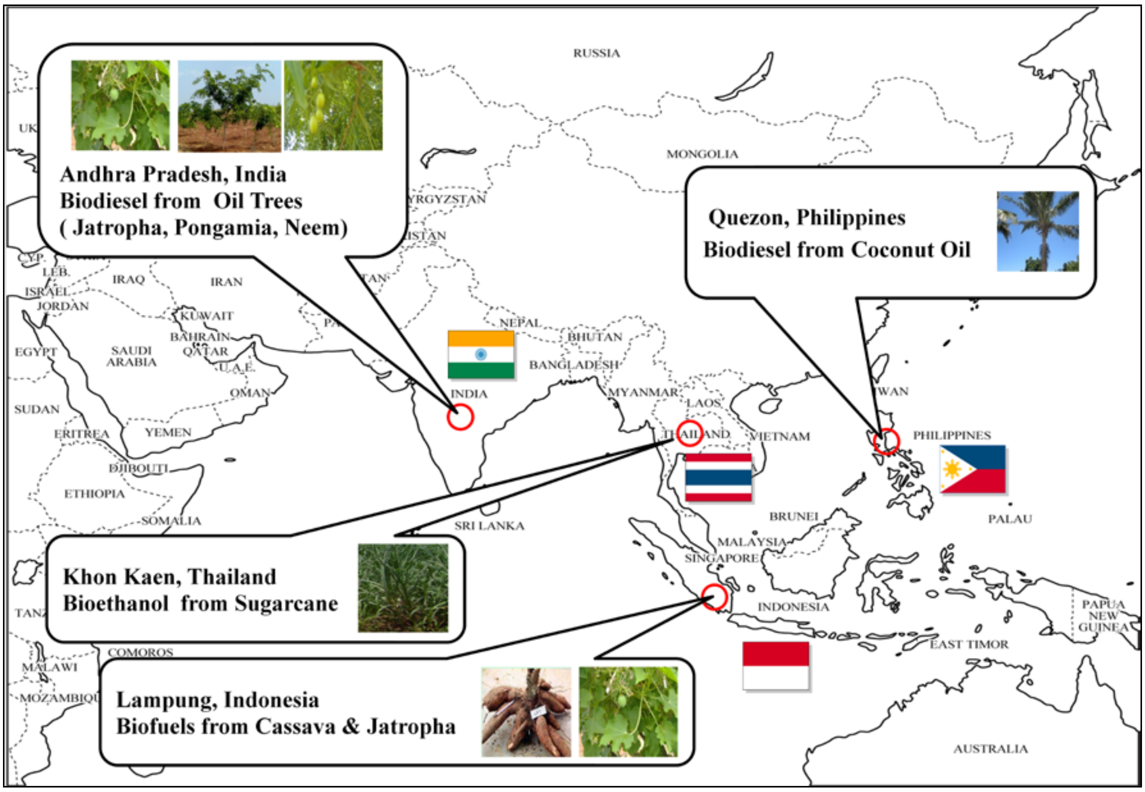

Figure 3-1 Location of four pilot projects with different feedstocks used for biofuels

A brief description of the case studies is provided as follows.

Indian pilot study focused on biodiesel production using Jatropha and other tree borne oils (TBOs) and was conducted in the state of Andhra Pradesh. Government of India (GoI) has released the National Biofuel Policy in December 2009, and accordingly, a biofuel blending of 5% to 20% in fossil fuels has been recommended in next 5-10 years. Since diesel consumption in the country is almost 80% of the total transport fuel consumption, government policy focuses more on biodiesel production. The GoI is encouraging the exploitation of waste lands for cultivation of oil trees, such as Jatropha and Pongamia, and use TBOs as raw material for biodiesel production. The case study included three companies situated in the state of Andhra Pradesh (AP) and working on various aspects of biodiesel production chain using TBOs, the main being *Jatropha curcas*. The state of AP has a large area of waste lands falling in semi-arid zones, houses the first and largest biodiesel production plant, and also has initiated biomass energy activities in the country, and hence, was selected to implement the Indian case study.

Indonesian case study follows the National Energy Policy of Indonesia, which expects that by 2025 the share of biofuels should be increased to at least 5% of the national energy mix. The study aimed at the sustainability assessment of utilisation of Cassava and Jatropha for biomass energy production in Lampung Province. Cassava and Jatropha are used as the raw material to produce bioethanol and biodiesel, respectively. *Jatropha curcas* was selected as primary bioenergy crop for study on biodiesel production as it can be grown as inter-crop with other traditional crops on existing arable lands, and hence, it does not compete with the food production. Jatropha plantation also grows on variety of lands with much lesser efforts and care than those required by the traditional crops.

The study in the Philippines assesses the sustainability of utilisation of coconut and its oil for biodiesel production in Quezon Province. The area selected for the study has a high production of coconut as well as high concentration of biomass based industries. The province has a potential of increasing the value added generated from biomass production. Also, with the mandate of the Biofuels Act of 2006, of implementing higher blending rates of biodiesel with fossil diesel in near future, Quezon's production of coconut methyl ester (CME) is likely to increase substantially. Three major CME plants are located in the province, which also have a huge potential for employment generation.

In pilot project of Thailand, the sustainability of biomass utilisation has been assessed for a sugar biorefinery complex in Khon Kaen province. The study focused on sugarcane utilisation for ethanol (via molasses) production and for electricity (via bagasse) production. The study covered various components of bioethanol production chain including sugarcane cultivation, sugar production, bioethanol production from molasses, and power production from bagasse and organic fertilizer from filter cake.

The details of each case study and the results of its sustainability assessment are given in the following sub-sections.

3.2. Pilot Study in Andhra Pradesh, India

3.2.1. About the Study Sites

The pilot project study in India involved detailed study in the state of Andhra Pradesh (AP), which is the fifth largest State in India. AP is a densely populated and partly a drought prone state. Despite being one of the pioneering states in adopting Jatropha cultivation for biodiesel production in 2005, the state had some discouraging experiences with the promotion of Jatropha. Due to this experience, the state also brought in focus on promotion of Pongamia, and other oil trees such as Simaruba. Pongamia is a local species in the state, the leaves of which have long been used as organic manure. The goal of the state government is to achieve 100,000 acres of biodiesel plantations in 13 districts of the state in order to make productive use of degraded land.

Three sites selected for the pilot study are located around the capital city of Hyderabad. The plantation of Tree Oils India Limited (TOIL) and Nandan Biomatrix Limited (NBL) are situated near Zaheerabad town in Medak district. While the plantations of TOIL are actual field crops, NBL's plantation is used for conducting research and development activities on Jatropah and other oil trees. The third site was a biodiesel production plant of Southern Online Biotechnologies Limited (SBTL) located in Nalgonda district. Some brief ideas of these sites are given in the following paragraphs.

The plantation of TOIL is a 120 acres farm located near Zaheerabad Town and is developed on almost barren land with rocky soil unfit for agriculture. The plantation includes Jatropha (40 acres), Pongamia (60 acres), and 20 acres of other oil trees.

The company has involved local people in the project and intends to create many such projects, which could be a viable option for the farmers and villagers. The company also plans to tie up with farmers through contract farming and execute plantation projects on turnkey basis with profit sharing basis. Presently, the company is mainly involved in plantation, seed production and also has a small scale oil extraction unit. It uses the tree oil within its in-house needs such as to run electric generator, tractors and other facilities and also sells it in the local market. But in future it plans to set up a 2 TPD biodiesel plant in a central location of the cluster of villages and establish about 50 Rural Energy Centres (RECs) across India. In addition to main product, i.e. oil seeds, the company developed several ancillary activities on the farm which include apiculture, animal raring, poultry, vermiculture, composting, biogas from animal dung, etc. These activities, on one hand, are catering to the daily needs of farm workers, these are generating some revenue for the company right from the first year of the plantation, on the other hand.

Plantation of NBL is also located near Zaheerabad town and mainly consists of Jatropha. The company has conducted an extensive research and field work on various aspects of Jatropha plantations in its endeavour to bring in more benefits to the farming community and contribute to the cause of Indian economy. It has developed Jatropha hybrid varieties, which may give up to 7 tonnes yield of seeds per ha and up to 3 tonnes of oil per ha (in comparison to 1 tonne of oil under normal variety). NBL is involved in Contract Farming, Direct benefit through Estate Farming, Partnership with village Panchayats and Farming in forest lands. Company is providing many support services to the farmers and they have potential to earn a stable income 45000 INR per ha from fifth year onwards by adopting NBL’s hybrid cultivation.

SBTL's biodiesel production plant is located in district Nalgonda of AP and has a capacity of 40 TPD of biodiesel. The plant is designed to produce biodiesel from a variety of raw materials such as non-edible vegetable oils (Jatropha, Pongamia, etc.), Palm Sterean oil and Animal Talo. The company projects itself as an eco-friendly greenfield company, which is involved in biodiesel production by developing wastelands through oil tree plantations, employing tribal and rural folks, saving foreign exchange on reduced diesel imports and reducing GHGs and other local pollutants by substituting biodiesel, as a blend, in the fossil diesel. It is to be noted that presently the availability of Jatropha or other oil tree seeds is not enough and cost effective for the company. Hence, SBTL uses combination of various feedstocks such as non-edible vegetable seed oils, fish oils, animal fats, fatty acid and used cooking oil to produce biodiesel and glycerine.

Figure 3-2 depicts an integrated flow chart of biodiesel production using Jatropha and other Oil Seeds as raw material, involving three case studies selected, in Andhra Pradesh, India.

Figure 3-2 Various unit processes of biodiesel production using Jatropha and other oil seeds as the raw material in India

3.2.2. Application of Assessment Methods

Based on the guidelines developed by the expert WG of the ERIA, environmental, economic and social impacts have been estimated during the cultivation stage (for TOIL) and biodiesel production stage (for SBTL).

Economic viability of the Jatropha utilisation is expressed in terms of total net profit, personnel remuneration, tax revenue generation, and foreign trade impacts. The ***Total Net Profit (TNP) Before Taxes*** used in this study, is the sum of the value added in terms of net profit before tax generated out of the main product and the by-products from conversion or processing expressed as;

$$TNP = NPa + NPb,$$

where, NPa is net profit from main product and NPb is net profit from by-products.

The value added in terms of net profit for both the main products and the by-products can be computed using the following equations;

$$NPa = GRa – TCa; \text{ and,}$$

$$NPb = GRb – TCb;$$

where, GR is Gross or Total Revenue, TC is Total Cost (suffix “a” refers to main product and suffix “b” refers to by-product).

Job creation is another indicator for assessing the economic impact of the biomass industry. The quantum of jobs created per ha of plantation or per tonne of biodiesel production is a good indicator for assessing the impact of biomass industry on employment generation. The number of jobs generated with the presence of the bioenergy project is computed as follows.

Employment = Total Production × Labour Requirement for every unit produced

or

Job Created per unit of output = Total production / Number of person employed.

Government revenues in terms of taxes collected from the different key players of the biomass industry prove to be another economic benefit worthy of valuation. In India, agricultural income is fully exempted from paying taxes. Bioethanol already enjoys concessional excise duty of 16% and biodiesel is exempted from excise duty. No other taxes and duties are proposed to be levied on biodiesel or bioethanol.

Biomass production and processing has positive effects on foreign trade which is determined by two factors, viz., foreign exchange earnings and foreign exchange savings. Foreign exchange earnings arise from the gains of exporting the readily convertible material for biodiesel production. Foreign exchange savings can be accumulated from reduced diesel imports due to blending of biodiesel in fossil diesel. Biodiesel is expected to at least displace, if not replace fully, a fraction of the overall diesel consumption of an economy, which would eventually decrease imports of fossil diesel.

Finally, the TVA to the economy refers to the total contribution of the biomass industry to the economy in terms of net profit after tax of stakeholders in the production and processing of biomass; total employment cost or wages and salaries paid to the employees in the biomass industry and tax revenues collected from the different key players of the biomass industry.

Thus,

Total Value Added (TVA) = Total Net Profit (TNP) + Personnel Remuneration + Tax Generated

Based on the above concepts, the TVA per ha of Jatropha in various stages of biodiesel production is given as follows.

i) NP in Cultivation Stage (NPcult) = (Sales)seeds - (COP)cult;

where, *(COP) cult* is the cost of plantation per ha

ii) NP in Oil Extraction Stage (NPoilext) = (Sales) oilext - (COP)oilext;

where, *(COP) oilext* is the cost of plantation per ha *iii) NP in Transesterification Stage, (NP)trans = (Sales)trans - (COP)trans;* where, *(COP)oilext* is the cost of plantation per ha

TNP in terms of per ha of plantation

TNP = (NP)cult + (NP)oilext + (NP)trans

For environmental impacts, it was assumed that the biomass derived biofuels reduce CO_2 emissions. This is mainly based on the fact that during consumption stage, oil trees till biofuel utilisation, need to be assessed to ascertain the environmental impact of biodiesel. For assessment of the environmental impact, WG has developed an eco-index based on which the impact have been estimated at farm level and biodiesel production plant level. The steps of GHG Index methodology are given as follows.

- Estimate the emission levels of 100% diesel (DE) as an aggregate across the entire lifecycle of diesel.
- Estimate the emission levels of 100% biodiesel (BDE) as an aggregate across the entire lifecycle of diesel.
- Arrive at the various blending levels of bioiesel (%BD) and diesel (%D)
- Compute the GHG Index as

  GHG Index = (%D × DE + %BD × BDE) / DE

Some major social issues of importance in biofuel production are employment generation, rise in income levels and improvement in living standards. Various stakeholders, particularly farmers, will be interested in getting involved in biofuel crops' plantation only when they are ensured to benefit economically. Measurement of social development, at micro level, in pilot study countries having different social conditions, was a difficult task, and hence, WG proposed to use UNDP's Human Development Index (HDI), and Gender-related Development Index (GDI), which are globally accepted. However, the sub-indices of HDI / GDI need data on relationship between income and life expectancy, income and education, etc., which is not available at micro level (such as project site or village level). Hence, this information at macro level (state/ province/ national) has been used for micro level estimations and comparisons.

To capture some country-specific social issues, in addition to HDI and GDI, some other social development indicators (SDIs) at micro level were also estimated. However, as explained earlier, it is to be noted that these SDIs may not be comparable at international level and same SDI may carry a different meaning in different countries.

3.2.3. Results and Highlights

Estimation of environmental, economic and social impacts during Jatropha Cultivation stage and Biodiesel Production stage are being described as follows.

3.2.3.1. Jatropha and Oil Tree Cultivation Stage

Data and information from the Tree Oils India Limited (TOIL) was used for the assessment during cultivation stage of the Jatropha and other Oil Trees (mostly Pongamia). TOIL's plantations are an integrated and well managed farm with all types of wastes are being recycled and utilised at the farm itself. In addition to oil seed production, several ancillary activities such as vermiculture, animal raring, biogas generation, growing of vegetable and other crops as inter-crops, etc., have been initiated to make the farm profitable during the initial stage of plantation having no or very low yield of oil seeds.

Economic returns and profitability from cultivation stage starts from third to sixth year, depending upon the oil tree. For example, in case of Jatropha plantation, it starts from third year, rises till fifth year and stabilizes thereafter but in case of Pongamia, profitable yield is achieved only after sixth year of plantation. The results of the economic analysis are expressed in terms of TVA and net profit, employment generation per unit of output and foreign exchange savings. The TVA and net profit during cultivation stage are 2.8 million INR and 1.6 million INR per ha, respectively. Job creation by per unit of yield of seeds is 0.112, which is not very efficient for the company but from social angle, it is quite impressive (in terms of rural employment generation). Forex savings of about 27,122 USD per year is expected to be added to the national economy, as a result of addition of biodiesel blending, and hence, reduction of fossil diesel imports in the country.

It is to be noted that while estimating economic returns the capital cost of land has not been taken into account. The capital cost for purchase of land in 2003, at the rate of 20,000 INR per acre, was 2,400,000 INR. However, the real estate prices have gone up drastically in last decade and as per information provided by the company, the price of purchased land presently stands about ten times i.e. at the rate of 200,000 INR per acre. Considering this appreciation in land cost, the project for the company is definitely a highly profitable venture in economic terms.

Environmental assessment of TOIL farms was conducted in terms of net CO_2 balance at plantation stage. The diesel requirement for operating the generator and tractor at TOIL farms is 400 L per month or 4800 L per year. The electricity is supplied at a subsidized rate (at 6 INR per unit) and about 5000 INR per month is spent on electricity for lifting ground water for irrigation of plants. Apart from electricity and diesel, another source of GHG emissions is fertilizer used during cultivation, which adds 1942 kg of nitrogen, 2913 of phosphorous and 1214 for potassium per year. These three items could be considered as main source of GHG emissions at the plantation stage. Thus, per year carbon emissions are 36.7 tonnes per year and 0.589 tonnes per ha per year.

Social impact assessment was based on employment generation and consequent rise in income of those employed in the process. Employment generation during oil tree cultivation stage is about 248 persons per ha of cultivation. During the field survey of TOIL's farms, it was observed that ten families of workers were staying at the farm permanently. The families reported that they were earning an average monthly income of 4000 INR per month after their employment in this venture. They also reported a substantial increase (a 60% jump) in their monthly income after their employment at TOIL.

Figure 3-3 shows the monthly income and expenditure pattern of families employed at TOIL. The average salary per person reported before and after the employment in TOIL plantation was 2500 and 4000 INR, respectively, which indicates a rise of about 60% in salary after the employment at SBTL plant. The increase in income also resulted in higher monthly expenditure on various items such as food, education and health. For example, monthly spending on food, education and health was 34%, 2% and 4%, respectively, before their employment at TOIL farms, which went up as 38%, 6% and 6%, respectively, after their employment in this venture.

Although the percentage under the head "others, which includes savings", declined from 60% to 50% but in absolute terms the savings of each family also increased.

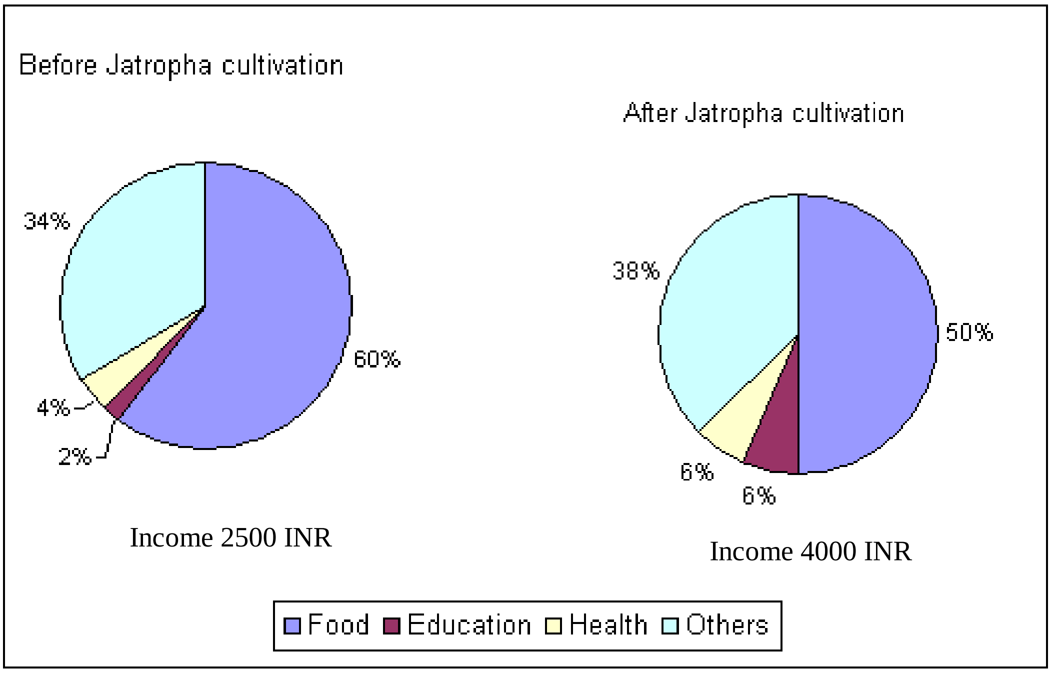

Figure 3-3 Monthly spending pattern and income of families affected by TOIL farms

The overall assessment of social development is expressed in terms of Human Development Index (HDI). Various sub-indices of HDI, viz., Life Expectancy (LE), Adult Literacy Ratio (ALR), and Gross Enrolment Ratio (GER) and per Capita Income (PCI) were calculated for the rise in income of the population affected by TOIL's activities. The new HDI value for the region affected by the TOIL is 0.615, which is higher by 0.003, in comparison to an average HDI of 0.612 for India (hence, the study regions), reported in HDR 2009. Similarly Gender-related Development Index (GDI) value for the region was estimated as 0.603, which is about 98.2% of HDI value.

Rise in income also resulted in raising the living standard of TOIL employees as they were able to spend more on basic necessities such as food, education and health. Some other Social Development Indicators (SDIs), which included use of clean fuel (biogas) by the workers' families, better housing, and increase in female literacy, better medical facilities, etc., were responsible for overall improvement in the standard of living of the people affected by the TOIL plantation.

3.2.3.2. Biodiesel Production Stage

Both Oil Extraction and Biodiesel Production Stages were assessed using data of Southern Online Biotechnologies Limited (SBTL). Assuming use of Jatropha and other oil seed as 100% feedstock and plant efficiency as 100%, the results of sustainability assessment of biodiesel production stage are analysed as follows.

Economic impact during production stage estimated the TVA of 519.7 million INR per year and net profit of 278.7 million INR per year which were very attractive for the company. The employment generated per L of biodiesel produced at SBTL is 0.002 person day per L of biodiesel produced, much more efficient then the cultivation stage, and is beneficial for the company. The foreign exchange savings due to use of biodiesel produced are estimated as 9.18 million USD per year, which is quite significant. Thus, comparison of biodiesel production stage with the plantation stage indicates that productivity is much higher in the biodiesel production stage. This is true for all agricultural activities when compared with manufacturing sector.

Environmental benefits in terms of GHG saving were also substantial during this stage. Although electricity is used to run the biodiesel plant but due to irregular electricity supply, the SBTL also uses a diesel run electricity generator. For generating heat and steam, rice husk is used as the main fuel in the boilers. Thus, for estimation of GHG emissions, diesel, electricity and rice husk have been considered and estimations show a net carbon saving of 2,763,609 tonnes per year, which includes savings from the consumption stage of biodiesel. This carbon saving may earn carbon credits through which company would be able to generate an extra revenue.

Social impact assessment was based on Monthly income and expenditure pattern of the persons employed at SBTL as given in Figure 3-4. Employment generation at SBTL was estimated as 40,150 person days per year, which translates to about 42 person days per ha of biofuel crop cultivation. The average salary per person reported before and after the employment in biodiesel plant was 2800 and 5300 INR, respectively, which indicates a rise of about 53% in salary after the employment at SBTL plant. Although total spending increased in all items but interestingly the percentage rise of spending did not increase, except for education which is increased marginally by 1%. The contribution towards the head “others, that includes savings,” increased substantially, which indicates that families are more concerned about their financial security in the future and probably use this money for better housing and similar other factors of raising their living standard.

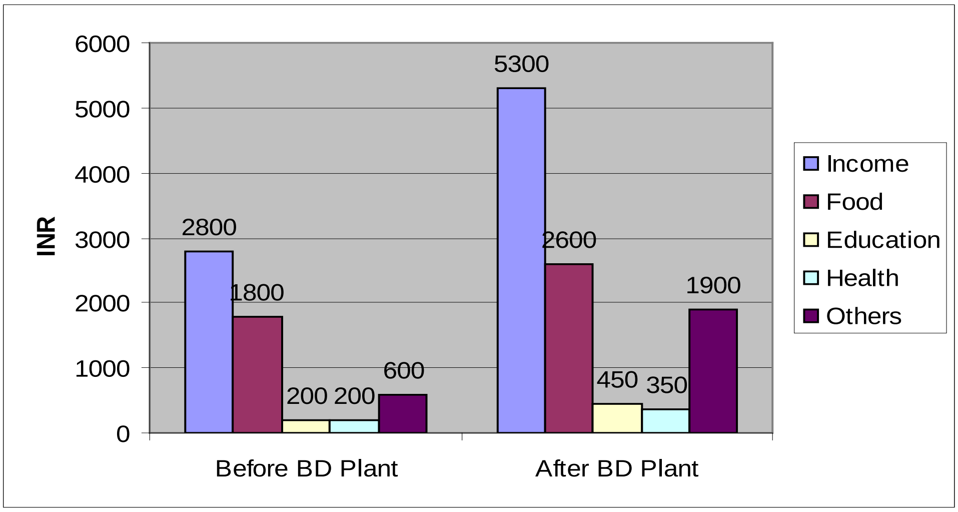

Figure 3-4 Monthly income and expenditure of workers at SBTL

In terms of HDI, the change was 0.004, over and above the average HDI of the region. A GDI value of 0.604 was estimated, which is slightly better than cultivation stage. Other SDIs, such as standard of living, education, health and dwelling units also reported a positive change, as above, and these were better than cultivation stage. Some other SDIs also improved as the workers and their families were able to afford better housing facilities, spend more on education, especially on female children, and medicines and also save more for their future needs.

3.2.3.3. Overall Impact Assessment

Table 3-1 summarises the overall impact assessment during the lifecycle of biodiesel production, which is based upon data analysis of two companies. The data used for Jatropha cultivation stage were obtained from TOIL and for oil extraction and biodiesel production stages were obtained from SBTL. The emissions from transportation of raw material and finished products or by-products have not been considered for estimation. The emissions from land use change have also not been considered. However, it is to be noted that, for TOIL farms, as waste land with negligible vegetation has been converted into plantation land, it may result in significant carbon sequestration. Consumption stage captures environmental analysis in terms of GHG savings only through use of biodiesel produced at SBTL. Economic benefits during biodiesel production are much higher than those from cultivation stage of Jatropha and other oil trees. Same is the case with the GHG saving potential and social benefits. Thus, overall assessment indicates a positive impact on environmental, economic and social aspects of the locality, where the plantation and biodiesel facilities are situated.

Table 3-1 Overall impact of biodiesel production

STAGE / IMPACT	Jatropha Cultivation (TOIL)	Biodiesel Production (SBTL)	TOTAL / AVERAGE
Economic			
GVA (INR)	2809245	519760000	522569245
Net Profit per year (INR)	1609245	278714000	280323245
Net Profit per ha per year (INR)	33139	6392	39531
Job Creation (per unit output)	0.112	0.003	0 057
Forex Savings (USD)	27123	9183160	9210283
Environmental			
GHG Emissions (t-CO_2/yr)	37	1631	1668
GHG Emissions per ha (t-CO_2 /yr)	0.589	0.041	0.630
GHG Savings during Consumption (t/ yr)	8072	2763609	2771681
Social			
Employment (PDs/yr)	12045	40150	52195
Employment (PDs/ha/yr)	248	42.19	290
Change in PCI (INR/yr)	1980	1999	1989
HDI (Actual)	0 615	0.616	0.616
HDI (UNDP for 2006)	0.612	0.612	0.612
Change in HDI	0.003	0.004	0.004
GDI	0.603	0.604	0.604
Other SDIs			
Living Standard (Rise per 100 HH)	19	28	24
Change in Literacy (Number per 1000 HH)	87	92	90
Change in female Literacy (Number per 1000 HH)	158	192	175
Change in Pucca Dwellings (Number per 100 HH)	15	22	19

Note: PD- person days; HH- Household

3.2.4. Suggestion for Sustainability Assessment

Overall assessment of lifecycle of biodiesel production using tree oils in India showed benefits in terms of environmental, economic and social aspects. However, it is to be noted that in this case both oil tree cultivation and biodiesel production activities are located in rural areas. Hence, if most of the activities related to biodiesel production chain are located in rural areas, chances of increase in rural employment are better.

It is observed that quantitatively most benefits are higher during the biodiesel production stage as compared to the plantation stage. But cultivation stage is more focused on rural areas, which is of particular importance in case of India and other developing countries in East Asia. And to sustain such activities in rural areas, it is necessary that interest of local stakeholders (small and marginal farmers, landless labourers, etc.) is encouraged through providing them various supports such as awareness, training, technical guidance, financial help, etc. Financial support for farmers is particularly needed during first few (non-yield) years of plantation so that they could sustain without any difficulty.

The companies involved in biodiesel production would sustain only when raw material (oil seeds) are available in sufficient quantity and at a reasonable price. As observed in the Indian study, due to unavailability of oil seeds, use of other feedstocks by biodiesel producers defeats the basic purpose of the concept "biodiesel production using tree oils."

Research and development activities can play a crucial role in increasing yield from oil trees and, if benefits of this research are extended to cultivators, it will increase economic returns per ha of cultivated area and farmers would be keen to take up oil tree plantations.

Initially, it was perceived that yield from Jatropha plantation would be sustainable even if it is cultivated in waste lands without any care. But this study found that for a sustainable yield of oil seeds, Jatropha plant needs all inputs and care required for a normal crop but, of course, in much lesser amount.

Apportionment of economic benefits among various stakeholders involved in biodiesel production chain should ensure equitable returns to each one of them. For example, while CERs accrued during consumption stage could be claimed by biodiesel production companies, the same during plantation stage could be assigned to farmers. This would enhance farmers' returns per ha of plantation, further encouraging them for involving in this activity.

For sustainability of biodiesel production from Jatropha and other tree oils, research on increasing the yield of seeds and oil content in seeds should be undertaken at war footing. These factors are important in attracting farmers and other stakeholders to get involved in biodiesel production chain.

This study gives some idea of assessment of sustainability of biodiesel production at micro level but it is difficult to apply its results at macro (national or regional) level. However, it gives an insight to initiate a larger scale study to obtain more accurate assessment at regional and national levels.

3.3. Pilot Study in Lampung, Indonesia

Pilot study in Indonesia was conducted in North Lampung on two feeds stocks, i.e. cassava-based ethanol production and Jatropha-based bioenergy at Self-Sufficient Energy Village (SSEV). According to BPS (2009), HDI (Human Development Index) of North Lampung district was 69.4 and it was ranked the sixth. In addition, the percentage of poor population in North Lampung was the highest (38.16%). This implies that the study area is considered as less developed in terms of human development.

Ethanol production from cassava at a commercial scale is quite new in Indonesia. The first ethanol factory with a capacity of 180 kL was operated since 2008 in North Lampung. Developing cassava-based ethanol is triggered by depleting fossil fuel reserves, increasing fossil fuel prices, and global warming issues.

Generally, cassava farmers in Lampung are planting two types of cassava species, namely, Kasetsrat and Thailand species. Kasetsrat species can be harvested within 10-12 months after planting with a productivity of 30-40 tonnes per ha and high starch content. Thailand species are harvested after 7-10 months with a lower productivity (20-25 tonnes per ha) and relatively low starch content. Hence, for an efficient ethanol production, factory recommended farmers to plant Kasetsrat species.

The cassava roots were transported to the ethanol factory after harvesting. The distance from field to the factory varies from 0 to 40 km (average 6 km). Besides cost of transport, these activities also release CO_2 to the atmosphere, which is a GHG and causes global warming.

Cassava root are processed at ethanol factory through several processes, such as washing, rasping, liquefaction, saccharification, fermentation, and distillation. In these stages, energy was needed and CO_2 was also released to the atmosphere. In addition to bioethanol as main product, the ethanol factory also produced wet cake, cassava peels, some soil as solid waste, and thin slop that has high concentration of organic matter. The solid wastes can be utilised as a raw material to produce compost. The factory collaborates with third parties to handle these solid wastes and produce compost. This utilisation system was developed to prevent environmental pollution and generate an additional income. Utilisation of compost as an organic fertilizer for contract farmers' land will improve the soil quality and increase productivity. The system can also reduce the consumption of chemical fertilizers which will reduce GHGs from fertilizer production and transportation stages. Other by-product or waste from ethanol processes is thin slop. This wastewater contains high concentration of organic matters and has high potential to produce CH_4 gas (biogas) through anaerobic digestion. The ethanol factory has utilised the thin slop to produce biogas but, till date, the biogas so produced was flared and not utilised as fuel. If the biogas was utilised as a fuel for power plant in the ethanol factory, it will reduce coal consumption and hence the CO_2 emissions.

Jatropha plantation studied is being developed under a concept called Desa Mandiri Energi or Self-Sufficient Energy Village (SSEV). The SSEV pilot based on Jatropha has been established in Way Isem, a village located in Sub District of Sungkai Barat, North Lampung District. The village is located at about 3 hours driving (160 km) from Bandar Lampung or about 44 km from district city (Kotabumi), and 17 km from sub-district (Sungkai Barat). The village is occupied by 1443 peoples with 739 (51,21%) male and 704 (48,79%) female comprising of 361 families and spread in an area of about 1350.867 ha. Most of villagers are working in the farm. Energy consuming activities of the villagers are basically for cooking and lighting, which are met by wood and kerosene. So far, there is no grid electricity installed at the village. The wood is gathered from the garden or farm for free; while kerosene is bought from the local suppliers.

The SSEV pilot project was sponsored by Eka Tjipta Foundation as a manifestation of CSR (Corporate Social Responsibility) from Sinar Mas group. It was initiated in 2007 when two representatives from Eka Tjipta Foundation visited Way Isem and introduced the SSEV concept based on Jatropha. The foundation provided 100 kg seeds for the whole community – or about 0.8 kg seeds for each involved family. Jatropha seeds can be processed to produce Jatropha oil and the oil is used to run generator set for electricity production. Later on, the foundation also provided 20 units of anaerobic digester to produce biogas fuel from the Jatropha cake. Other biomass waste from peeling and pruning is returned back to the field as compost.

The people in Way Isem were interested to cultivate Jatropha because they thought that Jatropha will benefit them with many uses. Jatropha is easy to cultivate and practically no fertilizer is required for the plant. So far, the pilot project involved a plantation area about 40 ha. It is required at least 7 months for Jatropha to produce seed (1 month in poly bag and 6 months in the field). The production of Jatropha is around 1 kg of fresh fruit per tree. The seed can be harvested twice a week. After peeling, 5 kg of fresh fruit gives 1 kg seed. The oil is extracted using a diesel-driven mill and every 3 kg seed produces around 1 L CJO (crude Jatropha oil) which is sold through Eka Tjipta. This practice need to be re-evaluated because, under the SSEV concept, the oil should be used to produce electricity for the community.

The community is organized under a cooperative unit (Koperasi) functioning as an agent to sell Jatropha products. The Koperasi is lead by the head of the village. The villagers collect and peel Jatropha nuts, and then sell the seeds to the Koperasi at a price of 1000 IDR/kg seed. The Koperasi processes the seeds to extract CJO. All the processing equipments like generator set, Jatropha mill, oil filter and degummer have been provided by Eka Tjipta.

The CJO is sold to Eka Tjipta at a price of 10,000 IDR per L. Therefore, the Koperasi gets 4000 IDR gross profit that is used to pay the cost for Jatropha processing and to run the Koperasi. Small part of the profit is returned to the Koperasi members as dividend.

To manage the waste resulted from Jatropha processing in a more beneficial way, Eka Tjipta also provided twenty units of anaerobic digester to the village. The digester is run using Jatropha cake to produce biogas fuel. The biogas is used to replace fire wood in cooking. Digester volume is 1200 L and need to be filled with 2 kg of Jatropha cake mixed with 18 L of water. The biogas generation system was practical and innovative one, but the villagers had very low knowledge on the safety and precautions to be observed during the process.

3.3.1. Results and Highlights

Table 3-2 shows environmental impact of ethanol production process using cassava roots starting from plantation to waste treatment. Regarding CH_4 gas released from waste treatment, there are three scenarios considered in the table: (1) biogas is flared, (2) biogas is merely released to the atmosphere, and (3) biogas is used to generate electricity by replacing a part of coal.

Table 3-2 CO_2 emission during ethanol production process

Process	Source	Unit*	Quantity	CO_2eq Emission*** (kg/L Ethanol)	(kg/GJ)
Plantation	Diesel fuel	L/ha	13.7	0.0097	0.4597
	Urea	kg/ha	192	0.0400	1.8957
	NPK (15-15-15)	kg/ha	185.5	0.0173	0.8199
	Herbicides	kg/ha	1.747	0.0739	0.3249
Transportation	Diesel fuel	L/t	0.41		
		L/kL ethanol	2.658	0.0082	0.3886
Processing	Coal	t/day	210		
		MW/kL ethanol	0.032	0.2143	10.1564
Waste treatment	CO_2	m^3/day	0**	0	
	CH_4, flared	m^3/day	0**	0	
	CO_2	m^3/day	0**	0	
	CH_4, vented	m^3/day	18957.9	1.5798	74.8720
	CH_4, utilised	m^3/day	18957.9	-0.029	-1.3744
TOTAL CO_2 EMISSION (SCENARIO 1, FLARED)				0.2965	14.0491
TOTAL CO_2 EMISSION (SCENARIO 2, VENTED)				1.8764	88.9223
TOTAL CO_2 EMISSION (SCENARIO 3, UTILISED)				0.2680	12.6974

**) every ha produces 4.394 kL ethanol*

***) neutral*

****) The CO_2 emission calculation was based on: IPCC 2006, West (2002), and (www. bioenergy. ornl. gov/papers/misc/energy_conv. html)*

Our observation revealed that CO_2 emission released by bioethanol production greatly depended on the utilisation of biogas produced from waste treatment. Sustainability assessment of cassava utilisation for bioethanol revealed that ethanol fuel potentially offered a CO_2 reduction by 85% to those of gasoline, given that biogas released from waste treatment is flared. It can be demonstrated from Table 3-2, that total emission of CO_2 equivalent resulted from ethanol production is 0.2965 tonne per kL ethanol being produced (14.0491 kg/GJ) if the biogas is flared. As can be seen from Figure 3-5, CO_2 released from power plant contributes the highest emissions, accounted for 72% of total emissions. If the biogas resulted from waste treatment is utilised to generate electricity in the power plant, the total CO_2 emission slightly decreases to 0.2680 tonne/kL (12.6974 kg/GJ). Although no much difference in terms of CO_2 emissions, using biogas in power plant will reduce coal consumption significantly. Our calculations revealed that the use of biogas may replace around 28 tonnes of coal per day (13.3%). If the biogas from waste is merely vented to the atmosphere, CO_2 emissions were 1.8764 tonne/kL ethanol or 88.9223 kg/GJ, meaning 5% higher than CO_2 emissions from gasoline production.

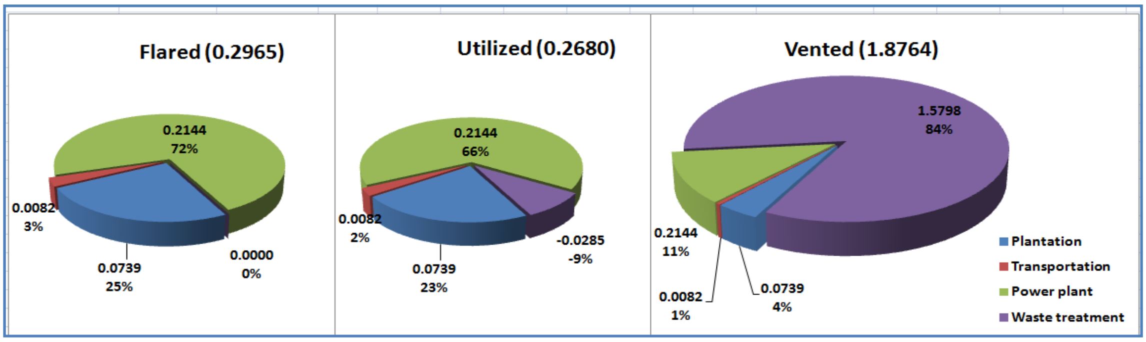

Figure 3-5 CO_2 emission ethanol production in t-CO_2eq/kL ethanol for different biogas treatment: (a) flared, (b) utilised in the power plant, (c) vented to the atmosphere as it is.

The production of ethanol from cassava has increased cassava price due to competition with tapioca factories. Cassava farmers received a profit of about 6,235,744 IDR/ha/yr for contract farming system and 4,995,916 IDR/ha/yr for non contract farming system. Processing cassava for bioethanol increased the value added of cassava about 950-1108 IDR/L bioethanol or about 146.6-171 IDR/kg cassava. Fluctuation of cassava price significantly affected to economic sustainability of bioethanol production. Calculated costs considered for economic evaluation include land rental, labour cost inside the family, depreciation, and seeds. Table 3-3 shows a breakdown of cost and revenue of cassava production, both for partnership and non partnership cassava farmers.

Processing cassava into ethanol is expected to bring about value added for cassava farming. It is required 6.48 kg of fresh cassava to produce every L of ethanol. At investment cost for ethanol plant 45 million USD, our observation found that ethanol production cost was 150-160 USD/kL ethanol excluding raw material (cassava).

Table 3-3 Costs and returns in cassava production for partnership and non partnership farmers

ITEMS		PARTNERSHIP FARMER			NON PARTNERSHIP FARMER		
		QUANTITY /ha	**COST/UNIT (in IDR)**	**COST/ha (in IDR)**	**QUANTITY / ha**	**COST/UNIT (in IDR)**	**COST/ha (in IDR)**
MATERIAL	Seed, fertilizer, compost, and chemicals	1 package	1,187,950	1,187,950	1 package	1,027,716	1,027,716
LABOUR	Weeding, fertilizing, and other maintenance	28.05 days	25,000	701,328	37.31 days	25,000	832,811
MACHINE	Land preparation	1 package	294,498	294,498	1 package	478,172	478,172
	Harvesting and Transportation	28,49 t	69,545	1,981,338	24,67 t	74,897	1,847,716
OVERHEAD	Tax, and rent, refraction			2,135,280			1,823,862
TOTAL COST				**6,300,394**			
TOTAL	**fresh cassava root**	28,490kg	**439.25**	**12,536,138**	28,490 kg	24,670 kg	**449.75**
NET PROFIT				**6,235,744**			**4,995,916**

At a cassava price of 439.25-449.75 IDR/kg and exchange rate of 9200 IDR a dollar, the total cost of ethanol production will be in the range of 4231 to 4388 IDR per L. Currently, ethanol price is 580 USD/kL ethanol or 5336 IDR/L. The value added resulted from ethanol processing was 950-1108 per L ethanol being produced or 147-171 IDR per kg cassava. Figure 3-6 shows the value added from cassava-based ethanol processing. Table 3-4 details cost and returns for ethanol production as well as additional profit from waste management.

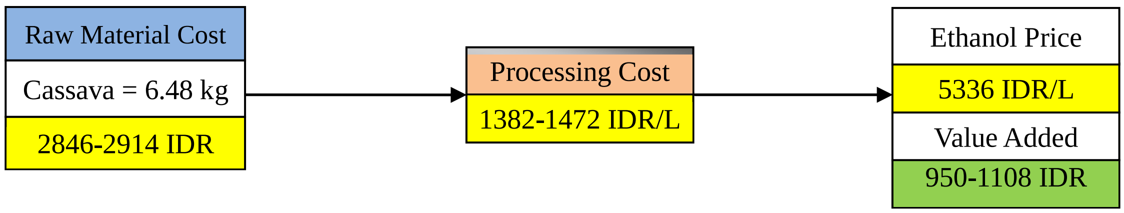

Figure 3-6 Value added resulted from processing cassava tubers into ethanol on per L ethanol basis

Table 3-4 Costs and returns in ethanol production in a ha cassava production

ITEMS		QUANTITY	COST/UNIT (IDR)	TOTAL (IDR)
TOTAL COST		4,466 L	**4,231**	**18,895,646**
TOTAL OUTPUT, L		4,466 L	**5,336**	**23,830,576**
SELLING PRICE PER L			**5,336**	
NET PROFIT				**4,934,930**
BY-PRODUCTS	Biogas	712 m^3	4,200	2,990,400
	Compost	1.37 t	700,000	959,000
ADDITIONAL PROFIT				**3,949,400**
TOTAL PROFIT				**8,884,330**

The utilisation of ethanol for biofuel needs additional processing to remove excess water. The fuel grade bioethanol will have price higher than 580 USD/kL ethanol or 5336 IDR per L. At present, it is difficult to utilise bioethanol as a biofuel in Indonesia because the gasoline price is subsidized by government. The subsidized price for gasoline (premium) is 4500 IDR, which is much cheaper than bioethanol price, considering almost similar production cost for both fuels. Thus, subsidy system should be adopted on bioethanol production if Indonesia wants to implement bioethanol as a biofuel mixed with premium. Enforcement from government is really needed to utilised bioethanol as a biofuel.

Increasing of cassava price, however, has a positive effect on farmers, who were willing to increase production by expanding cassava farming area. Thus, the existence of ethanol factory has given a positive impact in improving farmers' revenue by increasing production and price of cassava. However, high price of cassava has increased the production cost of cassava-based products, such as tapioca, citric acid, and bioethanol.

The ethanol production from cassava also has a positive impact to the social condition of the people who are settled around the factory. Increased income from cassava farming and better job opportunities for the local people around the factory has improved their living standard and life style.

It is revealed that HDI for the case of cassava farming is 0.542 or 54.2 %. This is far below the HDI of North Lampung, in general, which is reported as 69.4 for 2008. There are three factors affecting HDI, namely Life Expectation index, Education Index, and GDP index. The first two indices are nearly constant for some short period. The GDP index, however, is strongly determined by farmer income. Therefore, the higher the price of cassava, the better the HDI will be. Recently, for instance, the price for fresh cassava climbs to about 900 IDR. If this is the case, the income per capita will increase to 897 USD. HDI will change to 56.1 compared to 54.2 at an average price of IDR.445 for cassava. Productivity improvement on cassava farming systems is important to make significant increased of GDP. Government support to improve education enrolment through scholarship program is recommended also to increase HDI.

If cassava farming was assumed as an additional activity and previous GDP was assumed equal to GDP of Lampung Province (734.78 USD), cassava farming increased income per capita of farmers by 162.3 and 130.0 USD for partnership and non partnership system, respectively. The GDP index increased from 0.309 to 0.347 for partnership farming and from 0.309 to 0.347 for non partnership farming. Similarly, the HDI increased about 2.3% (from 54.2 to 55.5) for partnership farming and about 2% (from 54.2 to 55.3) for partnership farming. The higher HDI increasing for partnership farming system indicated that ethanol factory as a partner of cassava farmer has positive impact on the economic and social development of the farmer in the surrounding area of the factory.

The same indices were separately calculated for male and female to estimate Equally Distributed Index (EDI). Gender-related Development Index (GDI) was then calculated by simply taking non-weighted average of those three EDIs. The calculation and resulted GDI was tabulated in Table 3-5. It was revealed that GDI for cassava farmers in the field studied was 0.5416.

Table 3-5 Equally distributed index calculation along with resulted gender-related development index for cassava farming

Gender	LEI	EDI-LE	EI	EDI-E	GDPI	EDI-I	GDI
Female	0.5867	0.6141	0.6887	0.7073	0.285	0.3074	**0.5416**
Male	0.6433		0.7178		0.333		

Table 3-6 demonstrated that total emissions of CO_2 equivalent resulted from CJO production is 0.4374 tonne per kL of CJO being produced or 12.5862 kg/GJ. The CO_2 emission from plantation and Jatropha processing was 59% and 82%, respectively (Figure 3-7). Waste treatment to produce biogas reduced CO_2 emission by 41% of the total emission. In this case, Jatropha cake, waste from CJO processing, was anaerobically digested to produce biogas. The biogas was then utilised as fuel for kitchen stoves, replaced kerosene or woods. Our observation revealed that a family produced about one cubic meter of biogas a day that is equivalent to 0.6 L kerosene or 3.5 kg woods. Sustainability assessment of CJO production revealed that CJO potentially offered a CO_2 reduction by 86% to those of diesel oil, given that biogas released from waste treatment is used for cooking in the community.

Jatropha cultivation in Way Isem was not economically profitable (Table 3-7). The cultivation is labour intensive and seed price, on the other hand, is low. According to the Village Head, the selling price of Jatropha seed at 1000 IDR/kg is too low and a Jatropha farmer will get lesser money than that he (she) can get by working as a labourer. Currently, the daily wage of a labourer is 30,000 IDR. Therefore, a farmer will have to harvest and produce at least 30 kg seed to match the wage he gets by working as a labourer. In fact, it is difficult to realize this quantity, which is equivalent to 150 kg of fresh nuts. The nuts have to be peeled before it is handed to the Koperasi. Removing the skin of the nut is also laborious and so far it is conducted manually. These problems have made Jatropha plantation less attractive for the community.

Table 3-6 CO_2 emission during CJO production

Activity	Source	Unit	Quantity*	CO_2eq Emission**	
				(kg/L CJO)	(kg/GJ)
Plantation	Urea	kg/ha	24	0.0920	2.6464
	NPK (15-15-15)	kg/ha	16	0.0275	0.7914
	TSP (0-36-0)	kg/ha	17	0.0087	0.2505
	Herbicide	kg/ha	1.00	0.0721	2.0759
	Pesticide	kg/ha	0.74	0.0588	1.6914
Processing	Diesel fuel	L/ha	27.6	0.3076	10.3012
Waste treatment	CH_4, utilised	m^3	178.9	-0.1797	-5.1707
TOTAL CO_2 EMISSION				**0.4374**	**12.5862**

** based on a ha Jatropha production.*

*** The CO_2 emission calculation was based on: IPCC (2006), West (2002) and Augustus (2002).*

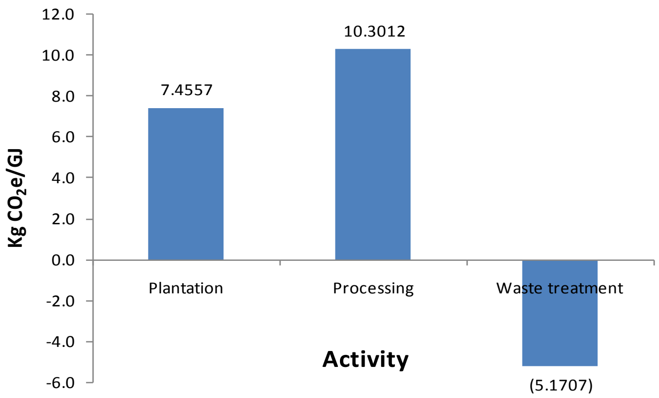

Figure 3-7 CO_2 emission from CJO production process.

Table 3-7　Costs and returns in Jatropha seed production

	ITEMS	QUANTITY / ha	COST/UNIT (in IDR)	COST/ha (in IDR)
MATERIAL	Seed, Fertilizer and Other chemicals, compost	1 package		214,648
LABOUR	Land preparation, planting, fertilizing, and other maintenance	64.11 day	24011	1,539,345
	Harvesting, peeling and Hauling	26.92 day	24011	646,376
TOTAL COST				2,400,369
TOTAL seed		790 kg	**1,000**	**790,000**
NET PROFIT				**-1,610,369**

Processing Jatropha into CJO is expected to result in value added for Jatropha production. Every 5 kg of Jatropha nuts was peeled to produce a kg Jatropha seeds. The seeds then were processed into CJO and required 3 kg to produce per L CJO. Our observation found that production cost was about 1000 IDR/L CJO excluding raw material (seeds). Currently, CJO is sold a price of 10,000 IDR/L. The value added resulted from CJO processing was 1000 IDR/kg seed (Figure 3-8).

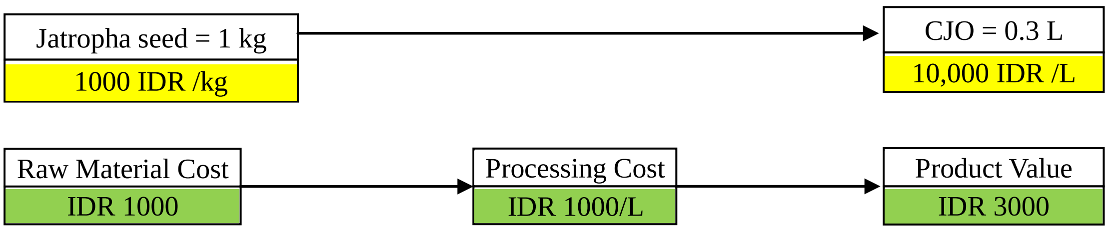

Figure 3-8　Value added resulted from processing Jatropha seeds into CJO on a kg seed basis

Economic benefits of Jatropha production can be optimized by using all Jatropha wastes such as Jatropha cake to produce biogas and Jatropha peel, wet cake, and sludge for compost (Figure 3-9). Assuming the price for simple organic fertilizer at around 700 IDR/kg, our analysis on a ha basis revealed a significant additional economic benefit resulted from optimum waste utilisation (Table 3-8).

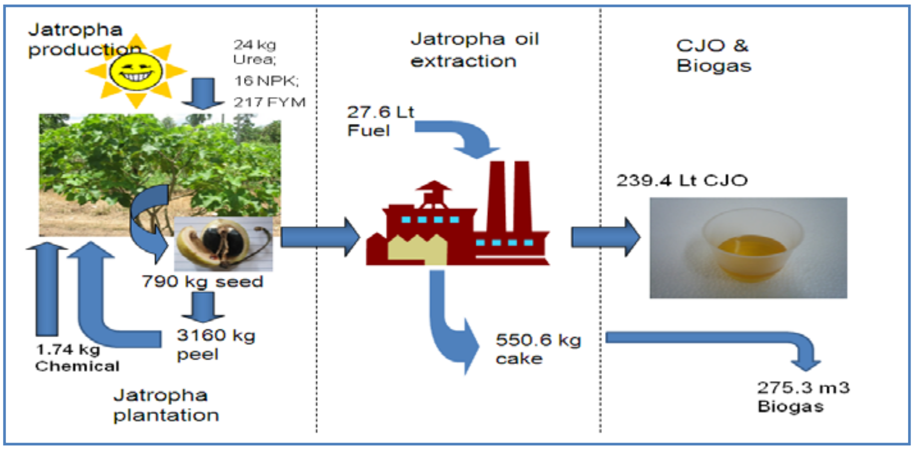

Figure 3-9 Material balance of Jatropha processing based on a ha of plantation

Table 3-8 Costs and returns in production of CJO from one ha Jatropha production considering a maximum use of waste

ITEMS		QUANTITY	UNIT COST (IDR)	TOTAL (IDR)
Direct Costs	Seed input cost	790 kg	1,000/kg	790,000
	Labour cost	790 kg	1,000/kg	790,000
	Fuel	27.6 L	5,000/L	138,000
	Sub-Total			**1,718,000**
Overhead	Miscellaneous (helper, fees, taxes, and administration)			0
TOTAL COST				**1,718,000**
TOTAL OUTPUT, L CJO		**239.4**	**10,000**	**2,394,000**
NET PROFIT				**676,000**
BY-PRODUCTS	Jatropha peel (0.4 factor)	1264 kg	700	884,800
	Biogas from Jatropha cake*	275.3 m^3	4200	1,156,260
	Solid/sludge fertilizer	550.6 kg	630	346,878
ADDITIONAL PROFIT				**2,387,938**
TOTAL PROFIT (IDR/ha) from processing				**3,063,938**
TOTAL PROFIT (IDR/ha) from farming and processing				**1,453,569**

** 1 m^3 biogas is equivalent to 0.6 L kerosene*

With CJO yield of 239.4 L/ha and CJO price of 10,000 IDR, it can be showed that total revenue will be 4,781,938 IDR/ha. Therefore, the economic benefit is improved to 1,453,569 IDR. This was not a bad economic activity given that Jatropha is planted as intercropping.

It is revealed that HDI for the case of Jatropha farmer was 0.3534 or 35.34 %. Again, the HDI for Jatropha farmer was also far below the HDI for North Lampung in general. This implied that life quality, education, and income for the people in Way Isem were quite low. Therefore it is important for them to work hard to improve their life expectation and income as well. Government support to improve health quality by establishment local health center (Puskesmas) is also imperative.

Jatropha production and processing increased income per capita of farmers by 39.5 USD. The Jatropha production and processing increased GDP index from 0.195 to 0.214 and increased HDI about 1.8 % to 36.0. Even though still lower than HDI of North Lampung district, the Jatropha production and processing activities successfully increased HDI, meaning that Jatropha production and processing activities biofuel production from Jatropha and their waste utilisation has positive impact for social development.

Similar GDI calculation for Jatropha farmers has been performed and the results were tabulated in Table 3-9. It was revealed that GDI for Jatropha farmers in the field of study was 0.351.

Table 3-9 Equally distributed index calculation along with resulted gender-related development index for Jatropha farming

Gender	LEI	EDI-LE	EI	EDI-E	GDPI	EDI-I	GDI
Female	0.0817	0.0993	0.7503	0.7726	0.1549	0.1877	**0.351**
Male	0.1250		0.7950		0.2352		

Based on the assessment through pilot study, it is clear that sustainability of cassava and Jatropha utilisation for bioenergy would be increased through utilisation of waste or by-product from each step of processing. The utilisation of waste biomass increased gross value added, created new job, and decreased GHGs emission. The utilisation of waste biomass from cassava and Jatropha for biogas and biofertilizer also reduced fossil fuel and chemicals fertilizer consumption, created clean energy sources, and increased the accessibility of rural people to energy and fertilizer. Development of integrated system in plantation and biofuel industry is greatly recommended to increase the sustainability of soil, reduce environmental impact, and optimize social and economic benefits.

3.3.2. Suggestion for Sustainability Assessment

Guidelines of the ERIA's Working Group were successfully used to assess the sustainability of ethanol production from cassava and biodiesel from Jatropha as well as biogas generated from their wastes at community level. Implementation of this assessment method at macro level, such as province level, should be evaluated. Output of the above studies could be useful for sustainability assessment at national (country) or East Asian region level.

Dissemination of the WG Guidelines in other East Asian Countries is needed. Experience and results of the pilot studies could serve as a guide in the efforts of other East Asian Countries and other international organizations such as Global Bioenergy Partnership (GBEP) and ISO in biomass assessment.

3.4. Pilot Study in Quezon, the Philippines

The study was conducted in an area where biomass is known to have high production level and there is a high concentration of biomass-based industries. The province of Quezon was selected based on the following reasons: (1) Among the coconut-based provinces in the country, Quezon has the largest volume of production and is heavily dependent on its two major agricultural products, rice and coconut; (2) Having several rice and coconut-based industries, Quezon has the potential of increasing the value added generated from biomass production; and, (3) With the mandate of the Biofuels Act of 2006, of implementing a higher blending rates of biodiesel to fossil diesel in the coming years, Quezon's production of coconut methyl ester is likely to increase since there are three major CME plants located in the province.

The study aims to test the methodologies for the calculation of indices for sustainability of biomass (coconut) utilisation for biodiesel production in Quezon. This will help determine the issues and constraints of the stakeholders in biodiesel production, which the policy makers can take up while framing and implementing policies and programs that would really help the concerned stakeholders. It also aims to help the key players/agents to determine whether there is a need to improve, change, or adopt new technologies for a better outcome from their ventures.

3.4.1. Results and Highlights

3.4.1.1. Economic Indices

The sustainability of biomass utilisation was assessed using the indicators of the economic benefits as described earlier. The methodologies for the calculation of economic indices of biomass utilisation were tested using actual data from coconut farmers, copra processors, oil mills, and coconut methyl ester (CME) manufacturers.

In the determination of the value added, the different product forms of coconut in Quezon were considered. The product flow was divided into four stages (Figure 3-10). First stage is the *Production of Mature dehusked coconut*. This stage accounts for the costs incurred in the actual production process of the raw material or initial product which is the mature dehusked coconut. Second stage is the *Copra Production.* This stage involves the processing of the mature dehusked nuts in to copra Third stage is the *Coconut Oil Production.* This stage involves the processing of copra into crude coconut oil and further processing of crude coconut oil into refined coconut oil, specifically RBD which is refined, bleached and deodorized coconut oil. The final stage is the *CME or Biodiesel Production*. This involves esterification of the refined oil to produce the final product which is biodiesel. Table 3-10 lists the recovery rates of each product form.

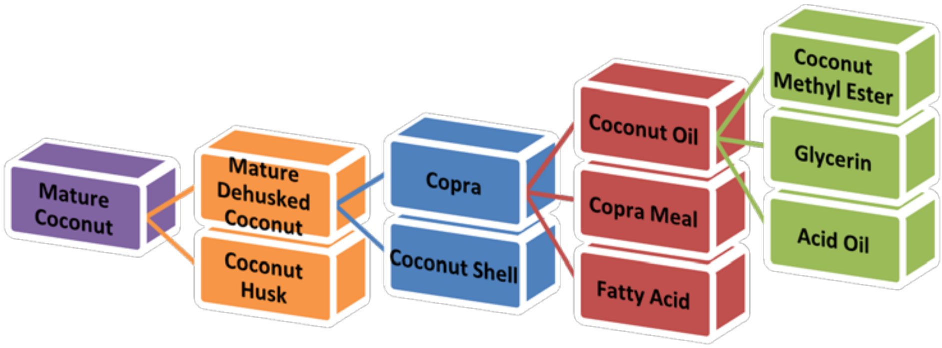

Figure 3-10 Product flow of coconut

Table 3-10 Recovery rates per coconut product form

PRODUCT FORM	RECOVERY RATE
Mature dehusked nut	67% of mature husked nut
Husk	33% of mature husked nut
Copra	33% of mature dehusked nut
Shell	22.4% of mature dehusked nut
Crude coconut oil	61.5% of copra
Copra meal	32% of copra
Refined coconut oil	92.5% of crude oil
Fatty acid	4.9% of crude oil
CME	100% of refined oil
Glycerin	12.5% of refined oil
Acid oil	0.55% of refined oil

(1) Net Profit per Product Form

The net profit for each product form from the primary input to the final product, that is from dehusked nut to biodiesel is summarised in Table 3-11. Net profit per unit is highest for copra at 6.76 PHP/kg and lowest for CME at 0.122 PHP/L. Including the revenue from the by-products, the same trend is observed with copra production giving the highest total profit. The cumulative total profit for all product forms is almost 38,000 PHP equivalent to 845 USD.

Table 3-11 Summary of net profit per unit and per ha by-product form

PRODUCT FORM	NET PROFIT (PHP)		BY-PRODUCT SALES (PHP/ha)	TOTAL PROFIT (PHP/ha)
	Per unit	Per batch (ha)		
Dehusked Nut, kg	2.42	15,544.00	0	15,544.00
Copra, kg	6.76	14,352.32	1,320.00	15,672.32
Refined Oil, kg	1.25	1,512.33	3,849.22	5,361.56
Biodiesel (CME), L	0.122	160.63	1,260.86	1,421.49
TOTAL		**31,569.29**	**6,430.08**	**37,999.37 (845 USD)**

(2) Total Value Added

Table 3-12 shows the summary of the total value added per product form generated from the per ha production of mature nut up to processing into biodiesel or CME. The total enterprise profit amounts to 37,999 PHP with total wages paid of 13,764 PHP and generating a tax revenue of 7,859 PHP per ha per year. The total value added for all the value adding activities amounted to 59,623 PHP (1,325 USD) per ha per year with dehusked mature nut production contributing the highest amount (44.5%) followed by copra production (38.5%).

Considering that around 230,440 ha in the province of Quezon are planted to coconut, the total TVA from the biodiesel industry would be 13.74 billion PHP if the mature nuts production in the province will be processed into biodiesel.

Table 3-12 Total Value Added per year by-product form per ha of biomass utilisation

PRODUCT FORM	TOTAL PROFIT (PHP/ha)	WAGES PAID (PHP/ha)	TAX REVENUE (PHP/ha)	TOTAL VALUE ADDED (PHP/ha)
Dehusked Mature Nut	15,544.00	11,000.00	exempted	26,544.00
Copra	15,672.32	1,800.00	5,485.31	22,957.63
Refined Oil	5,361.56	350.00	1,876.54	7,588.10
Biodiesel (CME)	1,421.49	614.42	497.52	2,533.44
TOTAL	**37,999.37**	**13,764.42**	**7,859.38**	**59,623.17**

3.4.1.2. Social Indices

(1) Human Development Index (HDI)

The minimum and maximum values adopted for life expectancy at birth are based on the values being used by UNDP and HDN. Using the data for Quezon shown in Table 3-13, the life expectancy index, $\mathbf{I_1}$ is computed as **0.75**. The computed literacy index, $\mathbf{I_2}$ is **0.937** and income index, $\mathbf{I_3}$ is **0.6678**.

Table 3-13 Quezon statistics as of 2007

	Male	Female
Proportion to total population	51%	49%
Life expectancy at birth (years)	67.33	72.89
Weighted average for Quezon (years)	70.05	
Literacy rate	96.8	96
Weighted average for Quezon	96.4	
Combined Gross Enrollment Rate (CGER)	87.5	88.9
Weighted CGER	88.19	
Income	16,430.167	13,917.75
Weighted average Income	15,148.83	

Source: NSCB 2007

Using all the computed values and substituting in the formula,

$$\mathbf{HDI = (I_1 + I_2 + I_3) / 3}$$

the computed HDI is now **0.784933.** The percent change in HDI in Quezon is calculated by subtracting the current HDI for Philippines which is 0.771 from the calculated HDI in Quezon given below as:

Percent Change in HDI = 0.784933 – 0.771 = **0.003933**

(2) Gender-related Development Index (GDI)

The gender-related Development Index (GDI) is calculated to reflect inequalities between men and women in all the three dimensions in HDI. For calculating equally distributed index for three in the following formula is used.

$$\text{Equally Distributed Index} = [\{(\text{female population share}) / (\text{female index})\} + \{(\text{male population share})/(\text{male index})\}]^{-1}$$

Then, the GDI is calculated by taking the average of equally distributed index of all three indices discussed earlier. Using the formula used earlier for both male and female and the data in Table 3.3-4 yield the values in Table 3-14.

Table 3-14 Indexes for male and female in Quezon

ITEM	MALE	FEMALE
Percentage share	51	49
Life Expectancy Index (LEI)	0.7055	0.798167
Adult Literacy Index	0.968	0.96
Gross Enrolment Index	0.875	0.889
Education Index (EI)	0.937	0.936
GDP Index (GI)	0.784108	0.784933
Equally Distributed LEI, EDLEI	0.748056075	
Equally Distributed EI, EDEI	0.9365097	
Equally Distributed Income Index, EDII	0.667759641	

Using all the equally distributed indexes in Table 3.3-5, the computed GDI which is the average of the three indices is now 0.7841085.

(3) Other Social Indicators

To determine the social impact of the biodiesel project, coconut farmers and employees of the case enterprises for the different product stages were interviewed. In terms of the effects of the biomass project specifically coconut production on their level of living condition, the majority (66%) of coconut farmers perceived that there has been an improvement in their living condition due to coconut farming. Seventy six percent reported that their income increased and they were able to provide better education for their children. Majority (84%) of the farmers experienced improvement in their relationship with other workers or farmers in the community.

On the other hand, in terms of the effects of employment in biomass project on the level of living condition, majority (57%) of employees perceived that there has been an improvement in their living condition due to their employment in their respective biomass project. The employees of the copra plant registered the highest satisfaction where around 93% experienced improvement in their level of living due to their copra employment. On the other hand, majority of the CME and oil mill employees reported no change in their living conditions.

All the copra employees reported that their income increased and they experienced improvement in their relationship with other employees. Majority of the copra employees also reported improved health conditions and provision of better education for their children as the benefits from their employment in the copra plant. On the other hand, only 58% and 54% of the oil mill employees reported improvement in their health condition and better education for their children resulting from their employment in the oil mill, respectively. However, majority experienced improved income and relationship with other employees.

In the case of employees of the CME plant, only 57% of the employees reported increased income and better education for their children as their benefits from their employment in the firm, although around 86% experiences improved relationship with other employees. However, 71% of the employees reported that their health condition did not improve at all.

In general, it could be seen from the results that majority of the employees benefitted from their respective employment in the biomass production and processing into biodiesel. Thus a major social impact of the biomass project can be measured in terms of the improvement in the level living of living conditions of the stakeholders in the biomass project.

3.4.1.3. Environmental Indices

Figure 3-11 shows the material/energy inputs and the corresponding GHG emissions in all the five main stages of the CME production; nursery, cultivation, copra processing, coconut oil production and CME production. The GHG emissions from each stage are summarised in Tables 3-15 to 3-19.

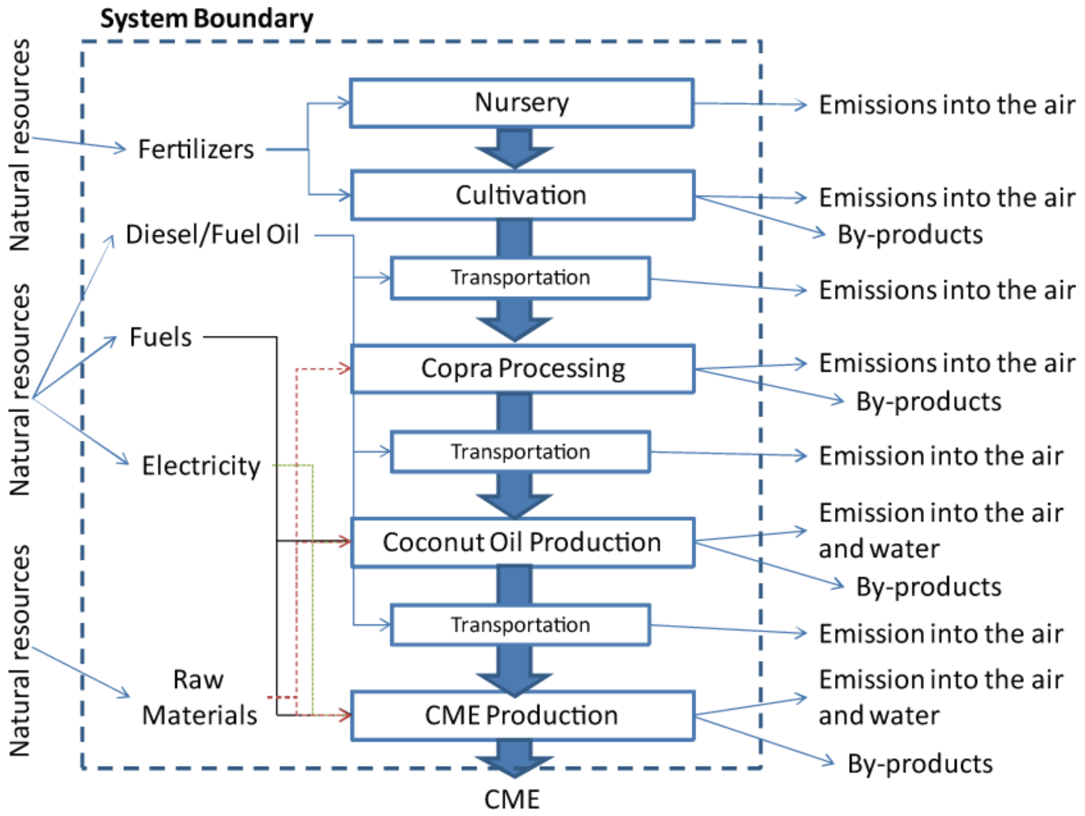

Figure 3-11 System boundary in CME production

Table 3-15 Material/energy inputs in the nursery stage

	Material/Energy Inputs [/tree/yr]	Data Source of GHG Emission Factors
Fertilizer production	2.1 kg	PRé Consultants (2006)
Fertilizer application	1.0 kg-N	UNFCCC (2007)

Note:

- *The product from this stage is seedlings of coconut.*
- *The number of trees planted in 1 ha is 250.*

Table 3-16 Material/energy inputs in the cultivation stage

Material/Energy Inputs [/ha/yr]		References
Fertilizer production	50.2 kg	PRé Consultants (2006)
Fertilizer application	13.8 kg-N	UNFCCC (2007)

Note:

- *The life span of coconut is assumed to be 80 years.*
- *The GHG emissions from harvesting and processing mature coconuts are zero because those are done by hand.*
- *The product from this stage is dehusked coconuts.*

Table 3-17 Material/energy inputs in the copra processing stage

Material/Energy Inputs [/ha/yr]		Emission Factors	References
Fuel consumption by diesel truck	12.8 L	3.1 kg-CO_2eq/L	RTFO (2008)
Dehusked coconut combustion	3120 kg	300 kg-CH_4/TJ 4 kg-N_2O/TJ	IPCC (2006)

Note:

- *The heating value of copra shells is 19.808 MJ.*
- *The GHG emissions from coconut juice are not taken into account because the juice is left on the ground or evaporated by heat.*
- *The economic allocation was applied to allocate the GHG emissions from this stage to two products; copra and shell. The selling prices of copra and shell are 46706 and 4320 [PHP/ha/yr], respectively.*

Table 3-18 Material/energy inputs in the coconut oil production stage

Material/Energy Inputs [/ha/yr]		References
Diesel	11.1 L	RTFO (2008)
Phosphoric acid	18.3 kg	PRé Consultants (2006)
Coal	99 kg	IPCC (2006)

Note:

- *The economic allocation was applied to allocate the GHG emissions from this stage to three products; CNO, copra meal/cake, fatty acid and waste water which are sold for 50,724, 2,377.76, 1471.46 and 0 [PHP/ha/yr], respectively.*

Table 3-19 Material/energy inputs in the CME stage

Material/Energy Inputs [/ha/yr]		References
Diesel	0.483 L	RTFO (2008)
Bunker fuel	52.11 L	IPCC (2006)
Water	1612 L	JEMAI (2005)
Electricity	69.10 kWh	Estimated from Table 3-21
Methanol	168.5 kg	PRé Consultants (2006)

Note:

- *The economic allocation was applied to allocate the GHG emissions from this stage to three products; CME, glycerin and acid oil which are sold for 58076.23, 1207.729 and 53.14 [PHP/ha/yr], respectively.*

The GHG emissions of electricity in Philippines are estimated by the types of power plants and the electricity generated per year which are shown in Table 3-20.

Table 3-20 The types of power plants and their specifications in Philippines

Type	Electricity Generated [kWh]	Thermal Efficiency [%]	Heating Value [MJ/kg]
Coal	13,503,727	32.5	28.5
Oil	1,928,244	32.5	43.6
Natural gas	19,575,855	47.5	51.9
Geothermal	3,729,921	47.5	-
Hydro	5,400,402	85	-
Wind	61,386	23	-
Total	44,199,534	-	-

The GHG emissions accumulated in each stage are shown in Table 3-21.

Table 3-21 Lifecycle GHG emissions of CME production

Stage	GHG Emissions [kg-CO_2eq/ha/yr]	Percentage [%]
Nursery	17.47	1.379
Cultivation	89.48	7.062
Copra Processing	193.38	15.261
CNO Production	329.6	26.011
CME Production	637.2	50.287
Total	1267.13	100.00

The largest GHG emissions are from the CME production stage and the second the CNO production. The emissions are from feedstock productions and energy consumptions. A total of 1,319.91 L of CME produced from 1 ha of plantation. If it is assumed that 1 L of CME is able to replace 1 L of petrolic diesel, the GHG emissions avoided by replacing 1319.91 L of petrolic diesel are

$$1319.91 \times 3.1 = 4091.7 \text{ [kg-CO}_2\text{eq/ha/yr]}$$

The net GHG savings per ha and per year are

$$4091.7 - 1267.13 = 2823.97 \text{ [kg-CO}_2\text{eq/ha/yr]}$$

It can be concluded from the results that CME production contributes GHG emission reductions.

3.4.1.4. Summary and Conclusion

The four economic indicators identified in the WG guidelines developed to assess economic sustainability of biomass utilisation are- annual net profit, employment and personal remuneration, tax revenue and net foreign trade impact. There are value addeds in each of the four stages of biodiesel production from coconut in terms of net profit, wages and taxes generated. There is a small positive change in HDI amounting to 0.0039 as a result of the coconut production and processing in the province while the gender related development index as measured by GDI is 0.7891. The largest GHG emissions in the four stages of production of CME come from the CME production stage and the second the CNO production. A total of 1,319.91 L of CME is produced from 1 ha of plantation. Replacing petrolic diesel with the CME production per ha of 1,319.91 L would result into a net GHG savings of 2823.97 [kg-CO_2eq/ha/yr]. Therefore CME production contributes GHG emission reductions. Using these three measures of indicators to evaluate the sustainability of coconut for CME production, the CME production is attractive from the business side, socially acceptable and environment friendly. This biomass utilisation would become sustainable.

The major constraints in coconut utilisation are the fluctuating price of copra in the market and the currently small market for biodiesel. Very low price of copra will not be attractive to coconut farmers while too high price of copra would not be attractive to oil and CME producers. The market demand for biodiesel is currently set at only two percent of the total diesel demand, which is very low for CME producers to sustain.

3.4.2. Suggestion for Sustainability Assessment

The sustainability of biomass utilisation can be looked at the different levels such as national level (from the point of view of the country or state), regional or province level (from the point of view of the region or province) and community level. In all of the three levels of biomass utilisation, there must always be a business component. As a business, the biomass utilisation should be profitable and that can be measured by the net profit as indicator. Employment and personal remuneration; and tax revenue can be used as indicators at all the three levels as well. The four plants evaluated in the Philippines, tax revenue applies only to Copra Processing Plant, Oil Processing Plant and CME Plant. Owners of the coconut plantation and farmers employed in the business are exempted from payment of taxes as part of the government's incentive to coconut growers. Foreign trade impact applies only to regional and national levels.

The Guidelines proposed the Human Development Index (HDI) as an overall measure of social development. This social indicator takes into account the measures for per Capita Income (GDP), Life Expectancy at Birth (LEI) and Adult Literacy Rate (EI). LEI, EI and GDP data are only available at the national level or at least in the regional level therefore HDI as measure of social development is more appropriate at the national or regional level. Other measures of social development are recommended to be used at the project or community level such as that of the coconut production, copra processing, oil processing and CME processing. Some of the recommended social indicators in the project or community level are increased income of the employee, better education for the children, improved health condition and probably improved relationship in the plant or community among others.

Life Cycle Assessment (LCA) has been suggested in the Guidelines as the indicator in assessing the environmental impact of biofuels. LCA as suggested in the Guidelines is limited to the quantification of greenhouse gases (GHG) expressed in terms of kg-CO_2eq. Evaluation of GHG using LCA seems to be the most appropriate approach in assessing the impact of the production of biofuels to the environment since GHG has been directly attributed to the increased atmospheric concentration resulting into the change in climate.

It is important to formulate a single questionnaire for the respondents that will capture the data needed for the calculation of the environmental, economic and social indices of the project/plant. There must be separate type of questionnaires for the producers and processors of biofuels. The respective questionnaires will then be tailored fit to target respondents hence specific information can then be collected from them. If possible, the person distributing the questionnaire should be properly trained in explaining to the respondents the intention of the survey.

It has been found that the use of the questionnaire alone was not sufficient to gather all the necessary data needed in the evaluation of environmental, economic and social impacts of the utilisation of biomass for biofuels. Whenever possible personal interview should be done in order to explain the questions and make follow up questions in order to capture the right information. Questions on economics particularly cost and revenue data are difficult to collect from the plant. Plant owners/managers/supervisors are quite hesitant in giving information on economics of the operations of the plant.

Social development data such as literacy rate, GDP, life expectancy are not available in the community level and so survey needs to be done to collect these data from the community. Data needed for the LCA such as fuel consumption per trip, number of trips made per year, electricity consumed for the year among others was also not easy to collect. These are information that you can only get from the plants record book. Without an access to these records it would be difficult to get accurate information.

From experience it is not enough to rely on the data given by the respondents' particularly technical data such as fuel consumption, efficiency and others. It is important that these technical data collected from the plant be verified from the literature. The calculation of all the indicators namely net profit, tax revenue, salaries/wages and foreign trade for the economics; HDI for the social impact and LCA for the environmental impact is not an easy task to do. Without proper training of personnel, the use of these indices will be a futile exercise. It is suggested that hands-on training/seminar on the calculation of these indicators be done for East Asian country representatives so that there will be transfer of knowledge. These participants will then conduct a trainers training to disseminate widely the use of the guidelines for the assessment of the sustainability of biomass utilisation.

3.5. Pilot Study in Khon Kaen, Thailand

3.5.1. Background

In Thailand, an agriculture based country, the government has encouraged production and use of biofuels in the transport sector (bioethanol and biodiesel) in order to reduce dependency on oil import and contribute to mitigate global warming impact and also to activate the grass root economy by stabilizing the income of farmers and generating employment in the local community.

With regards to bioethanol, the Thai renewable energy policy has been promoting the use of gasohol, a 10% blend of bioethanol with 90% gasoline, for substitution of conventional gasoline with a target to increase the use of ethanol up to 3 million L per day by 2011 and 9 million L per day by 2022. Also, ethanol producers have been encouraged to support the market through Board of Investment privileges for fuel ethanol plants with an 8 year free corporate tax.

Currently, cane molasses and cassava are the two major raw materials for bioethanol production in Thailand although the larger share is from molasses. Both sugarcane and cassava are good feedstocks for ethanol production as they are well adapted to the growing conditions of Thailand. Sugarcane is ranked the second most economic crop of the country just before cassava.

Khon Kaen province in Thailand has a very strong agriculture base with abundant rice, cassava and sugarcane farming. Thus, there are plenty of biomass resources, some of which are being used for non-food applications (fuel and fertilizer). There are already factories which have been producing ethanol for several years and in particular from sugarcane molasses. Therefore a sugar based refinery complex in Khon Kaen was selected as the pilot study site to test the indicators developed for assessing the sustainability of biomass utilisation.

The sugar based biorefinery complex studied in Khon Kaen is composed of several processing units as illustrated in Figure 3-12. These include a sugar mill, biomass power plant, ethanol plant and fertilizer plant.

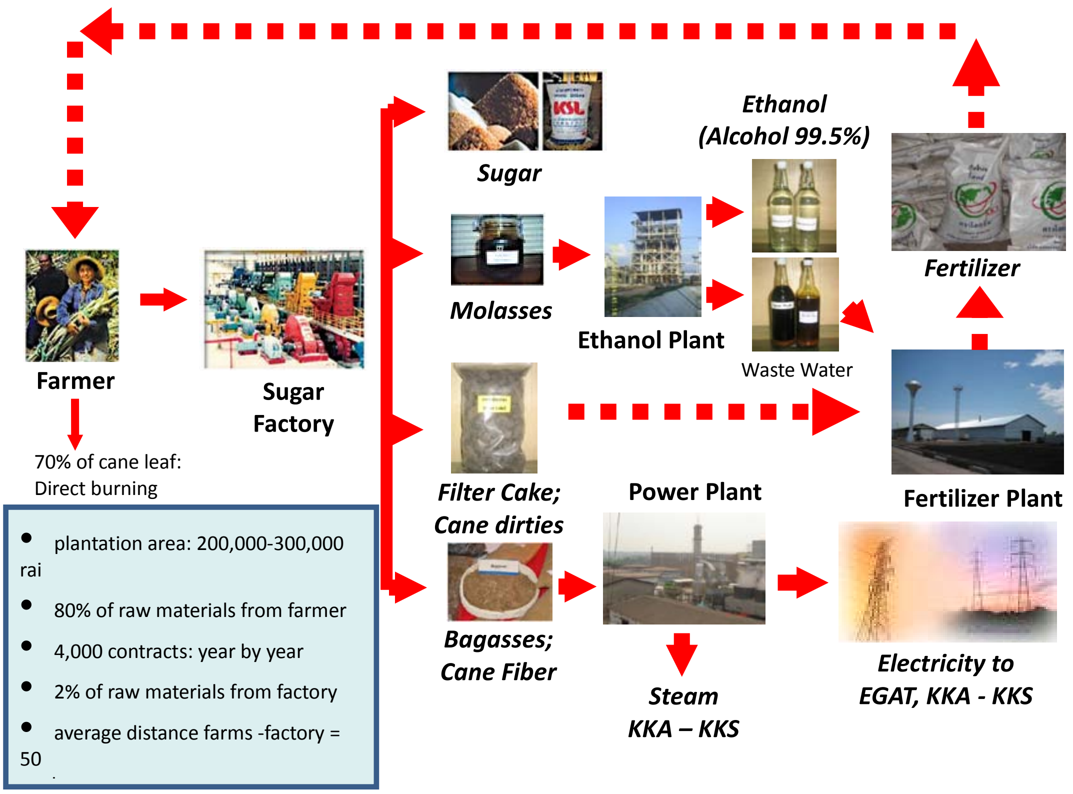

Figure 3-12 Biorefinery complex (Khon Kaen, Thailand)

(1) Sugarcane plantation

During the year 2009-2010, there were 4,000 contracted farms selling their sugarcane produce to the sugar mill of the biorefinery complex. This represents a total weight of more than 2 million tonnes sugarcane out of which 1.87 million tonnes were sent to the factory. The distance between the farms and the sugar mill does not exceed 50 km radius and the average amount of sugarcane per contract farm is about 515 tonnes. Trucks provided by the biorefinery complex are used to transport sugarcane from the farms to the sugar mill. Via contract farming, the farmers involved in the scheme are guaranteed the sale of their annual sugarcane production to the mill.

(2) Sugarcane processing

The main products from the sugar factory include raw sugar, white sugar, refined sugar and molasses. Bagasse is also generated from the crushing step of sugarcane. Generally, the company melts raw sugar and refines and purifies it even during the off season, to produce white and refined sugar. The company sells white sugar to the domestic food industries and also exports some to other countries. Refined sugar has higher purity than white sugar and is sold by the sugar mill to domestic pharmaceutical, food and beverages industries and some is exported.

(3) Ethanol and fertilizer production process

Molasses are a valuable by-product from the sugar refining process, brownish in color and characterized by low sugar content. One tonne of sugarcane processed yields about 45-50 kg of molasses. Molasses from the sugar mill is being sent to the ethanol plant of the biorefinery complex for biofuel production. The fertilizer production unit is a sub-unit process of the ethanol factory. It is produced from the filter mud that is obtained by filtering the sediment from the clarifiers under vacuum and is mixed with wastewater from the ethanol factory to produce general purpose granulated fertilizers. At present, the factory gives the filter mud to the cane-growers who supply sugarcane, for use in their farmland to support the sugar plantations in nearby areas. It is now being processed and mixed with wastewater produced from the ethanol plant to produce fertilizers which are to be sold to farmers as it is suitable for use in sugarcane fields.

(4) Biomass power plant

As mentioned earlier, bagasse is a by-product of the sugar mill from the crushing of sugarcane. At present the sugar mill uses part of the bagasse it generates as a source of energy to produce electricity and steam which are used in the sugar manufacturing process. The remaining part of the bagasse is sold to the biomass power plant of the biorefinery complex as raw material to generate electricity and steam which are in turn supplied to the sugar mill and ethanol factory. The excess electricity is being sold to the national grid.

3.5.2. Results and Highlights

(1) Social assessment

With regards to social assessment at the level of the sugarcane plantation and biorefinery complex, HDI was used as the main indicator to assess the level of social development. This was evaluated in comparison with the HDI of the province of Khon Kaen where the plantations and biorefinery complex are located. The change (difference) in HDI was used as a mean to assess social development for the population working in connection with the biorefinery complex. The results obtained from the pilot study are reported in Table 3-22.

Table 3-22 HDI results for pilot study in Khon Kaen

SOCIAL ASSESSMENT	Khon Kaen	Plantation	Bioenergy production
Life Expectancy at birth Indicator (LEI)	0.728	0.728	0.728
Education Index (EI)	0.888	0.888	0.888
GDP Index (GI)	0.673	0.593	0.776
HDI	0.763	0.736	0.797
CHANGE IN HDI	-	- 0.027	+ 0.034

From the results obtained it was found that HDI at the plantation for farmers was lower than that of the province i.e. negative change in HDI reflecting a lower level of development for that category of people. On the other hand, the HDI of the employees of the biorefinery is higher than that of the province.

This assessment indicates that the biorefinery complex set in Khon Kaen has not enabled the farmers to reach a level of social development that is higher than that of Khon Kaen. However, the negative change in HDI may not reflect the benefit that might have resulted from their contract with the sugar mill. Via contract farming, farmers are provided with a steady income for the year since their product (sugarcane) is guaranteed to be bought by the mill. This safety of a minimal income for the year is not captured by HDI, but is an important social aspect for farmers. Indeed, farmers in Thailand belong to a lower income class of the society and are therefore characterized by a social development that is lower than that of the average for the country. This situation is confirmed for the farmers selling their sugarcane to the mill in Khon Kaen. A comparison of their HDI with that of an average farmer in Khon Kaen (or national level) might show a positive change in HDI. This could be an additional option to assess if sugarcane farmers are really benefiting from their activities via contract farming with the sugar mill.

Concerning employees of the biorefinery complex, it is observed that their HDI is higher than that of Khon Kaen. This positive change in HDI reflects a higher level of social development due to a higher average income as compared to that of Khon Kaen.

For both the farmers and the employees at the sugar refinery, the HDI results are influenced by income since life expectancy index, literacy rate and gross enrollment were assumed the same as that of the national level. This assumption, based on constraints of time for collecting the required information, seemed quite reasonable for this pilot study particularly for education index (calculated based on gross enrollment and literacy rate) since enrollment and literacy rates in Thailand are high and an increase in income might not necessarily influence those aspects significantly.

(2) Economic assessment

With regards to economic assessment, total value added from the sugarcane plantation and biorefinery complex was considered. The information was calculated based on several factors including net profit, wages, taxes, and foreign trade earning. The overall results are presented in Table 3-23.

Table 3-23 Total Value Added per year from sugarcane cultivation and biorefinery

ECONOMIC ASSESSMENT	PRODUCT FORM		TOTAL VALUE ADDED (THB/yr)
	Plantation (THB/yr)	Khon Kaen Biorefinery complex (THB/yr)	
Total Net Profit	393,681,432	956,712,601	1,350,394,033
Wages Paid	708,125,095	760,810,000	1,468,935,095
Tax Revenue	13,625,940	357,494,553	371,120,493
Foreign Exchange	-	525,008,930	525,008,930
TOTAL VALUE ADDED			3,715,458,551

At the level of the overall biorefinery complex including sugarcane plantation, the results shown in Table 3-23 indicate that total net profit and wages combined represent 76% of the total value added; the remaining 24% being shared by taxes and foreign trade earning. Hence, salaries and profits are major benefits from the pilot study. With regards to taxes, it is important to highlight that based on the Thailand Board of Investment regulation on biomass utilisation, ethanol factories and biomass power plants are exempted from paying taxes for a certain number of years.

Regarding the economic assessment results of the sugarcane plantation, it is observed that major contributors to the total value added are from the salaries paid to farm labourers for their cultivation activities, almost 64% of total value added, and from profits generated out of the selling of sugarcane to the mill, about 35% of total value added. Tax revenue contributes the remaining 1%. Therefore at the sugarcane plantation level, income generated out of the farming activities and selling of sugarcane to the mill are major economic assets; the farmers themselves are mainly benefiting from the activities associated to the biorefinery complex. Those are important indicators since they imply that living conditions of farmers are likely enhanced thanks to the employment opportunity and income generation associated with the cultivation and selling of sugarcane to the sugar mill. Although the results of the economic assessment show economic benefits for the farmers which could lead to improved social development (via better living conditions from enhanced earnings), results from the social assessment part could not allow confirming such improvement since the information is not captured by HDI. It is important that the results from the economic assessment and social assessment be evaluated in combination in order to come up with a better understanding of the impacts of the biorefinery complex on the people part of its activities.

At the level of the biorefinery complex, results show that profit is a major contributor to total value added, about 37%, followed by salaries of employees at about 29%. Taxes are contributing 14% of total value added and foreign trade earning about 20%. This latter is based on the assumption that molasses based ethanol produced at the biorefinery complex enables to avoid importation of a certain volume of gasoline and therefore provides some potential savings. The economic assessment at the level of the biorefinery complex provides results that are quite different from those obtained at the level of the plantation. Profits are major assets to secure sustainability of operations of the biorefinery complex and represent the largest share of total value added. As for farmers, the biorefinery complex is contributing to providing employment opportunity and income, the latter contributing the second largest share of total value added. Social assessment at the level of the biorefinery complex provided positive results with regards to HDI, which was essentially influenced by income (the average income for a worker in the biorefinery is higher than that of Khon Kaen). Therefore, in this particular case, results of the social and economic assessment are seen to be in agreement. However, it is observed that contrary to the situation at the plantation, income is not contributing the largest share of the total value added due to the nature and scale of the activity concerned i.e. industrial (biorefinery complex) versus farming.

(3) Environmental assessment

Environmental assessment for this pilot study involved assessing global warming potential (GWP) associated to molasses based ethanol production and use. This assessment was performed by investigating GHG emissions from all stages associated to the production of molasses based ethanol from sugarcane plantation up to final stage of its production at the ethanol plant of the biorefinery complex. GHG emissions were also accounted for and allocated between the main product sugar and several by-products generated through the various processing units of the biorefinery complex. The by-products considered aside from the molasses produced at the sugar mill for ethanol production include fertilizer from filter cake and wastewater produced from the sugar mill and ethanol plant respectively, electricity and steam generation from bagasse left over residue from sugarcane crushing at the sugar mill (see Figure 3-12).

Several scenarios were considered to assess GHG emissions from the whole biorefinery complex as summarised in Table 3-24.

Table 3-24 Summary of scenarios in study

No.	Topic interest	Base scenario	Variation	
1	The guideline for allocation based on ISO recommendation to expand the system if possible.	Substitution of chemical fertilizer	Allocation by heating value	
2	Consideration of left-over steam	Waste (real situation)	Co-product	
3	Burning ratio of cane trash in sugarcane farm	70% (real situation)	0%	35%

From this lifecycle GHG emissions, result of the environmental assessment was expressed in terms of GHG savings based on the difference between GHG emissions from molasses based ethanol production and use, and GHG emissions from gasoline production and use. The lifecycle GHG emissions for the pilot study of Thailand are reported in Table 3-25.

Table 3-25 Lifecycle results of GWP for each scenario for the system of gasohol 95 and compared to gasoline 95

Phase	Gasohol 95 (kg-CO_2eq)					Gasoline 95 (kg-CO_2eq)
	Base Scenario	Scenario 1	Scenario 2	Scenario 3		
				0%	35%	
Production	<u>*3.97*</u>	3.91	3.74	3.22	3.46	<u>*3.45*</u>
Use	<u>*28.06*</u>	28.06	28.06	28.06	28.06	<u>*30.82*</u>
Total	<u>*32.03*</u>	31.97	31.80	31.28	31.52	<u>*34.27*</u>

Remark: 180 km test run by Toyota 1.5 L/1996 with gasohol 95 (14.95L) and gasoline 95 (14.78L)

The LCA (use and production) from base-case, scenario 1 and scenario 2 show rather similar amount of GHG emissions while for scenario 3 (0 and 35% of burning ratio of cane trash in sugarcane farm) slightly lower amount of GHG emissions are observed. System expansion is used for base-case scenario to avoid allocation as much as possible as recommended by ISO 14040. However, overall it can be seen that the variation in the results due to the various scenarios is within 2%; hence the base case results are robust and can be used for further analysis.

With regards to the results obtained over the entire lifecycle of ethanol production, the burning ratio of cane trash at the sugarcane plantation contributes to significantly affect GWP for this stage. GWP could vary as much as 47% if burning ratio was changed from 0% to 70%. However, the overall lifecycle GHG emissions associated to ethanol production (production plus use stage of gasohol) is not significantly different from that of gasoline, although slightly lower since only a 10% blend of ethanol is used. The maximization of utilisation of the by-products coming out from the various units of the biorefinery complex is contributing to reducing GHG emissions and therefore GWP associated to the various processing units of the biorefinery complex. However, the open burning of cane trash, although not contributing to significantly affect the overall lifecycle GHG emissions associated to ethanol production, should still be discouraged, and alternative use for energy purposes considered. This could help providing additional GHG emission credits for the biorefinery complex and hence further benefit to the environmental performance of ethanol as compared to gasoline.

3.5.3. Suggestions for Sustainability Assessment

Social development as characterized by HDI in this pilot study is mainly affected by the GDP index or in other words by income. However, since HDI only considers aspect of life expectancy, education and income, some other parameters for assessing social development study such as employment opportunity (for employees at the biorefinery complex) and safety of income (for farmers) are not captured by the indicator. Such aspects are important for assessing social development at community scale. HDI by incorporating aspects of life expectancy, education index and GDP index is suitable for national scale assessment of social development and ranking purposes. However, as seen in this pilot study, it is more difficult to adapt and provides limited information at local scale to evaluate social development/benefits that may have arisen from a particular project.

For future assessment it is imperative that the aspect associated to the nature and scale of the activities assessed be carefully considered to not distorting interpretation of results. Also, social and economic assessments are to be performed in an integrated way. As observed in this pilot study, the results of social and economic assessments are interlinked since social development is influenced by the involvement of people in activities contributing to economic output and generating income. It is imperative that those aspects be recognized to not bias the sustainability results obtained from the social and economic (socio-economic) assessments of an activity.

Life cycle assessment is a well-established, standard technique for quantifying GHG emissions. This is useful for calculating possible reductions in GHG emissions from any project as compared to a baseline. However, the issue related to allocation of emissions to co-products remains open to differences in methodological choices which can sometimes significantly affect the results. Narrowing the options for allocation may be a possible way to make the results comparable and consistent.

4. SUSTAINABILITY ASSESSMENT OF BIOMASS UTILISATION IN EAST ASIA

4.1. Environmental Aspect

The methodology for environmental assessment developed by ERIA's working group in the preceding phase (Refer to "Guidelines for Sustainability Assessment of Biomass Utilisation") was field-tested over a short period of six months in the pilot studies in four countries using different feedstocks , viz., Jatropha biodiesel in India, Jatropha oil and cassava ethanol in Indonesia, coconut biodiesel in Philippines, and sugarcane ethanol in Thailand. The Life Cycle Green House Gases (LC-GHG) emissions and GHG savings, selected as indicators of the environmental impacts, were successfully estimated in all the pilot studies.

The objectives of this field testing are to examine the applicability of the methodology developed for assessing environmental aspects and to evaluate the assessment results from the four pilot studies.

In this section, first of all, the data and information necessary for implementing the assessment are discussed. Although the procedures for Life Cycle Assessment (LCA) of LC-GHG emissions are standardised in ISO14040s or guided in the form of reports and books, some data and information, in addition to the primary and secondary data, on biofuel production were needed for their implementation.

Secondly, the findings from the result of each pilot study are discussed. LC-GHG emissions and their savings of biofuel production are highlighted here.

Finally, the difficulties faced and limitations of each pilot study are highlighted.

4.1.1. Data and Information Necessary for Implementing LCA

The assessments of the lifecycle GHG emissions were carried out in each pilot study using the methodology developed for this purpose. Although the procedures of Life Cycle Assessment (LCA) for GHG emissions are standardised by governments or international organisations (e.g. ISO14040s), some additional information collection other than the primary and secondary data were needed for the assessments. The following additional data were shared and used among the studies.

4.1.1.1. GHG Emissions of Fossil Fuel Production

To estimate GHG savings resulting from biofuel use, the GHG emissions of biofuel production are compared with those of fossil fuel production. For example, GHG savings resulting from bioethanol use are calculated from the difference in LC-GHG emissions between gasoline and bioethanol since bioethanol use is expected to replace gasoline consumption. However, GHG emissions from fossil fuels vary with countries, estimation methods, assumptions, etc. In addition, there are no such data of GHG emissions from fossil fuels that are estimated in a way common to the four countries, although there exist some data developed individually by the national projects of some countries. Here, the GHG emissions of gasoline and diesel in Renewable Transport Fuel Obligation (RTFO) of the United Kingdom are adopted because they have been used for the same purpose and currently used for calculating carbon intensity in order to award the Renewable Transport Fuel Certificates in UK market. The lifecycle GHG emissions of gasoline and diesel are 84.8 and 86.4[g-CO_2eq/MJ-LHV], respectively. The emissions cover oil extraction, oil transport, oil refining and use in vehicles, but not domestic distribution.

4.1.1.2. Allocation

A single process may produce several products. In the pilot studies, it can be often seen that the plantation of crops produces several by-products other than a main product, such as bagasse, shells husks, etc. Since these by-products are often utilised as feedstock for heating or materials of other products, a part of GHG emissions from the plantation stage should be allocated to the products. ISO14049 recommends a guideline for avoiding the allocation by means of expanding the system boundary or setting a substitution scenario. However, it is often very difficult to apply it in practice due to the need for accurate identification of the substituted system and the additional data requirement thereof. If the “avoiding allocation” cannot be applied, the emissions are allocated to each product based on the value or property characteristic of the products.

The widely used allocation methods are;

- Mass Allocation (allocated by the mass of products)
- Energy Allocation (allocated by the heating values of products)
- Economic Allocation (allocated by market prices or selling prices of products)

In the pilot studies, we first adopted "avoiding allocation" according to the ISO recommendation. Secondly, if allocation was not avoidable, "energy allocation" was chosen for the following reasons.

- Mass allocation may not be appropriate if by-products are voluminous, particularly in the case where a large quantity of agro-residues generated from the plantation stage is one of by-products. A large portion of GHG emissions allocated due to a large quantity of the agro-residues may result in underestimated emissions of a main product.
- Economic allocation may not be suited to the products whose market prices fluctuate widely and quickly, e. g. the price of crops, agro-residues, etc.
- Heating value is one of the properties which the products themselves have. Energy allocation may be more appropriate if by-products are utilised for energy.

Lastly, if "energy allocation" was not applicable, "economic allocation" was applied.

4.1.1.3. GHG Emissions Resulting from Land Use Change

Land Use Change (LUC) mostly driven by the clearance of land to produce more biomass for biofuel is a highly significant factor in GHG emission accounting (e.g., Müller-Wenk and Brandão, 2010). However, the CO_2 emissions from LUC were excluded from the system boundary in the pilot studies due to the following reasons:

- Jatropha was planted in wasteland. (the pilot study in India)
- Jatropha was intercropped into the existing traditional crops. (the pilot study in Indonesia)
- Coconut was planted more than a century ago. (the pilot study in Philippines)

- Cassava and sugarcane were grown a couple of decades ago and have never been planted over main carbon sink such as primary forest, peatland, etc. (the pilot studies in Indonesia and Thailand)
- Standardised methodologies for GHG emissions from LUC are not yet to be established.

4.1.2. Findings from the Four Pilot Projects

The GHG emissions and savings from the lifecycle of biofuel productions in each pilot study are tabulated in Table 4-1.

Table 4-1 GHG emissions and savings in four pilot studies

	India	Indonesia			Philippines	Thailand
Feedstock	Jatropha	Cassava		Jatropha	Coconut	Sugarcane
Unit	t-CO_2eq /ha/yr	kg-CO_2eq /GJ		kg-CO_2eq /L	kg-CO_2eq /ha/yr	kg-CO_2eq /RF*1
Cultivation	0.589	3.50		7.46	106.95	124
Processing	0.041	10.2		10.3	312.42	12.0
Transport	-	0.39		-	-	121.2
Others (Waste treatment, etc)	-*2	-*2		-5.17	-*2	-14.7
Scenario Analysis	-	S1	Flared	-	-	Base case was compared with 3 scenarios
		S2	Vented			
		S3	Utilised			
Total	0.630	S1	14.0	12.6	1267.13	124.0 (Base case)
		S2	88.9			
		S3	12.7			
GHG Savings	$2.77x10^6$ t-CO_2eq/yr	S1	70.8	73.8	2824	41,955 t-CO_2eq/yr (Base case)
		S2	-4.1			
		S3	72.1			

Note;
**1) RF means 1000 kg of sugarcane.*
**2) '-' indicates that the values are integrated into the other stages or negligible.*

GHG savings are defined as the difference between the GHG emissions from the lifecycles of biofuel production and fossil fuel production. Positive GHG savings imply that biofuel production can contribute to the reduction of GHG emissions more than fossil fuel production.

The stages of the lifecycles were grouped into the four stages (cultivation, processing, transport and others) so as to quickly look into the results of the pilot studies by stage in a single table. It should be noted that this table was not compiled to compare one pilot study to another. Since the comparison is not the main objective, the pilot studies differ from one another in their time and special scales, system boundary, functional unit, feedstock, products, etc.

As mentioned in Chapter 2.4, the GHG taken into consideration are CO_2, CH_4 and N_2O. CO_2 is, for example, released from combustion of fossil fuels and some chemical reactions, CH_4 from biomass combustion and waste treatments, N_2O from fertilizer applications. It should be noted that CO_2 emissions from the combustion of biomass-derived fuels or materials such as biofuels, bagasse, rice and coconut husks, etc. are not counted in the pilot studies according to the carbon neutral concept.

The findings from each pilot study are summarised as follows.

4.1.2.1. India

The calculation of GHG emissions was carried out in the two stages in India; Jatropha cultivation stage at TOIL Jatropha plantation and biodiesel production stage at SBTL refinery. The GHG savings were estimated to be 277×10^6 tonnes per yr. The main sources of the emissions were electricity consumption in the biodiesel production stage and diesel consumption and fertilizer application in the cultivation stage.

4.1.2.2. Indonesia

The GHG emissions were assessed for two kinds of feedstock; Crude Jatropha Oil (CJO) production in Way Isem village where Jatropha was intercropped at community level under the scheme of Self Sufficient Energy Village (SSEV) program, and cassava bioethanol production in Lampung province where a pilot scale factory has been working since 1982.

In the CJO production, it was observed that GHG emissions from the plantation and CJO processing stages were 49% and 82%, respectively. It was found that the biogas utilisation from Jatropha cakes contributed to 41% of GHG emission reduction. Biogas produced from anaerobic digestion of Jatropha cake was utilised as fuel for kitchen stoves, resulting in replacing kerosene or wood.

In the lifecycle of cassava-to-bioethanol production, three different scenarios for the treatment of CH_4 released from waste water were taken into account; the CH_4 is I) captured and flared, II) released into the air, III) captured and utilised for generating electricity. It was found that the GHG emissions depended mostly on the type of CH_4 treatment adopted. The GHG emissions of biofuel production were slightly larger than those of fossil fuel production only in the case where the CH_4 was released into the air (scenarios II).

4.1.2.3. Philippines

The calculation of GHG emissions was carried out for the lifecycle of Coconut Methyl Ester (CME) production in Quezon, Philippine. The lifecycle stages took into account nursery management, land preparation, plantation, copra processing, Crude Coconut Oil (CNO) production, CME production and transportations. The finding from the result was that the largest GHG emissions are from the CME production stage and the second largest ones from the CNO production, and that those emissions were mainly from feedstock productions and energy consumptions. It was concluded that CME production could contribute to 2824 kg-CO_2eq/ha/yr of the GHG emission saving.

4.1.2.4. Thailand

The calculation of lifecycle GHG emissions was performed for the biorefinery complex consisting of sugar factory, power plant and ethanol factory in Khon Kaen, Thailand. This biorefinery complex produces not only ethanol, but also several types of sugars, electricity and fertilizers. In the study, GHG emissions in the base case were first computed throughout its lifecycle and then it was carefully analysed how GHG emissions would change with each of three scenarios in comparison with the base case.

The scenarios are as follows.

- Scenario 1: the GHG emissions computed by a different allocation method
- Scenario 2: the left-over steam hypothetically utilised
- Scenario 3: the decreased amount of cane trash burnt in sugarcane farms

The following observations were made from the overall results;

- The main contributors to GHG emissions are the processes of sugarcane plantation and transportation.
- Improvements to reduce GHG emissions are limited since a lot of improvements have already been made over the years.
- The open burning of cane trash in the plantation is one of the main contributors to GHG emissions.
- The overall lifecycle GHG emissions of ethanol turn out to be not significantly smaller than those of gasoline since only a 10% blend of ethanol with gasoline is compared to conventional gasoline.

4.1.3. Highlights of the Four Pilot Projects from Environmental Aspect

During field-testing of WG guidelines in the pilot studies, some difficulties in the implementation of guidelines were observed. The limitations and highlights of the results of pilot studies are described as follows.

- The lifecycle GHG and the resulting GHG savings as indicators of the environmental impacts were successfully estimated and analysed in all the pilot studies. It implies that the indicators can work out well for assessing environmental aspect.
- To adjust the different conditions of each study, minor modifications were made on the questionnaire developed by our working group for data collection.
- In the cultivation stages, fertilizer applications were one of the main factors of GHG emissions because GHG emissions were not only from fertilizer productions but also from N_2O emissions resulting from fertilizer applications.
- In biofuel production stages, it was often observed that the main factor of GHG emissions was the consumption of energy such as diesel and electricity.
- In all of the studies, there were difficulties in collecting primary and secondary data necessary for calculation of GHG emissions because of their availabilities. The development of common database for GHG emissions of some basic materials or processes can shorten the time consumed in the assessments.

- Biofuel productions in all of the studies could contribute to the reduction of GHG emissions regardless of their magnitude if by-products were treated effectively and maximally.
- Scenario analyses helped us understand how the results of the total GHG emissions are dependent on each GHG treatment option. For instance, the pilot study in Indonesia demonstrated that how the GHG emissions varied with the methods of treating CH_4, one of the by-products of wastewater processing. For another example the pilot study in Thailand revealed how large or small the difference in GHG emissions came out by allocation methods, by the ratio of cane trash burnt, and by whether or not the left-steam is utilised .
- Apart from global warming impacts caused by GHGs, some studies recognized the importance of other environmental aspects such as environmental impacts on air, water and soil qualities, loss of biodiversity, etc.
- The pilot studies differ from one another in the format of the report and the reference unit for GHG emissions and GHG savings. However, a common format may be worked out for readers of the reports to easily understand the results.

4.1.4. Constraints and Further Improvements for Environmental Sustainability Indicator

Biofuels are considered “sustainable,” particularly when we take into account the necessity for fossil fuel substitution and greenhouse gas mitigation. One of the most apparent rationales for “sustainability of biofuels” stems from the concept “biofuel production from biomass is largely carbon neutral” (i.e., CO_2 emissions from biofuel combustion is nicely offset by the carbon absorbed via photosynthesis during biomass growth). As exemplified in the pilot studies, favourable weather and soil conditions for biomass production in tropical countries make biofuels production advantageous in developing countries. The availability of land, water, and labour provide developing countries in tropical regions with a comparative advantage in growing biomass resources.

Definitely a renewable energy source, produced entirely from biomass feedstock, that has the potential to nicely resolve global energy supply constraints, climate change, and other interconnected environmental issues deserve much attention and focus. Aligned with the long-term objectives of promoting sustainable use of biomass, a robust and user-friendly environmental sustainability methodology/tool has been created by the WG members and ‘field tested’ in this project. There are however, recognizable areas that are necessary to be addressed to further enhance the work to offer a more holistic and complete approach to environmental sustainability indicators. In the attempt to further move the project forward, some of the efforts from published scientific reports are revised. According to Mayer (2008), the ‘sustainability’ of human-environment systems, in terms of biomass cultivation, growth and production; can be assessed by determining whether or not disturbances or disruptions to the natural environment occur – in terms of soil, land degradation, deforestation, loss if biodiversity, etc.

As presented by many other sustainability assessment studies, further work should be carried out in order to define suitable sustainability indicators (Mol, 2007; Kromer, 2010). In the myriad of debates revolving around the environmental benefits that biomass/biofuels seem to offer, one impending question comes to mind: “Is there enough land to produce both food and biofuel?”. This goes back to the LUC issue mentioned earlier (section 4.1.1.3), as already highlighted by many other scientists and researchers (e.g., Fargione, 2008; Lora, 2010; Müller-Wenk, 2010). The expansion of land for increasing the productivity levels of biomass resources to meet heightened biofuel demands may often translate into the stripping of rich tropical forest land and causing loss of carbon. This also results in increased vulnerability to soil erosion, decreased soil fertility, and the need for larger applications of chemical fertilizers (causing another GHG emission, N_2O, is generated from N-fertilizers). Some of these important environmental issues will be highlighted and addressed in the next project phase.

4.2. Economic Aspect

The economic indicators that were taken into consideration for calculating the economic impact of the bioenergy project are the following: 1) total net profit accumulated from biomass conversion or processing; 2) employment impacts created out of the biomass industry; 3) tax revenues generated from the different entities within the industries; and 4) foreign trade impacts in terms of dollar earnings and dollar savings.

4.2.1. Findings from the Four Pilot Projects

4.2.1.1. Philippines

In the computation for the costs and returns as well as the Value Added (VA), in terms of net profit generated for each conversion process, the product flow was divided into four stages. First stage is the *Production of mature dehusked coconut*. This stage accounts for the costs incurred in the actual production process of the raw material or initial product which is the mature dehusked coconut. Second stage is the *Copra Production.* This stage involves the processing of the mature dehusked nuts into copra. Third stage is the *Coconut Oil Production.* This stage involves the processing of copra into crude coconut oil and further processing of crude coconut oil into refined coconut oil, specifically RBD which is refined, bleached and deodorized coconut oil. The final stage is the *CME or Biodiesel Production*. This involves esterification of the refined oil to produce the final product which is biodiesel.

(1) Net Profit from Mature Dehusked Nut Production

Table 4-2 presents the costs and returns computation based on a 1000 mature coconut production per ha per harvest. One mature nut weighs 1.2 kg, on the average. Harvesting is done every 45 days so there are 8 harvests per year. The highest component of the total cost comes from labour during weeding, fertilizer application and maintenance of the coconut plantation amounting to 8,000 PHP per ha per year.

Mature dehusked nuts are sold at 4.50 PHP per kg. Since there are 8,000 nuts per ha, one ha would yield 9600kg of mature nuts using the weight of a mature nut which is 1.2 kg. Using the recovery rates of 33% for husk and 67% for duhusked nut, total yield is 6,432 kg of dehusked nut resulting to total revenue of 28,944 PHP. The value of coconut husks is negligible (only 0.06 PHP per kg) and they are not normally sold. Net profit amounts to 15,544 PHP (343 USD) per ha per year or 2.42 PHP per kg of dehusked nut.

Table 4-2 Costs and returns in mature dehusked coconut production

ITEMS		QUANTITY /ha	COST/UNIT (in PHP)	COST /ha (in PHP)
MATERIAL	Fertilizer and Other Chemicals	1 bag/yr	1200/bag	1200
LABOUR	Weeding, Fertilizing, and Other Maintenance	12 mandays/yr	250/m-day	3000
	Harvesting, Dehusking and Hauling	8000 nuts	1,000/harvest	8000
OVERHEAD	Transportation/Delivery Cost	8000 nuts	300/1000 nuts	2400
TOTAL COST				**13400**
			PHP/kg	**PHP/ha**
TOTAL mature nut (1.2 kg)		9600kg	**1.40**	**13,400**
TOTAL dehusked nut (67% recovery)		6432	**2.08**	**13,400**
PRICE of dehusked nut			**4.50**	**28,944**
NET PROFIT			**2.42**	**15,544**

Note: There are 8 harvests in a year, average yield is 10 nuts per tree per harvest

(2) Net Profit from Copra Production

The second stage is the processing of mature dehusked nut, specifically the coconut meat into copra. In this stage, the raw material or initial product undergoes processing up to the point in which the output is already a convertible material for biodiesel production. This involves the processes and extraction costs of copra from mature coconut. The case of Alvarez Enterprise’s coprahan was taken into consideration.

Table 4-3 summarises the costs and returns in copra production from per ha of mature nut production per year. Total cost amounts to 32,344 PHP which mostly comes from the cost of mature dehusked coconut which is the raw material in copra production. The amount of copra produced at 33% recovery is 2,122,56 kg resulting to a unit cost of 15.24 PHP per kg of copra. Copra is sold at 22.00 PHP per kg on the average thus revenue from copra sales is valued at 46,696 PHP and net profit is 15,672.32 PHP per ha per year.

A by-product of copra processing is coconut shell which can be used as charcoal or even as water filter. Part of the coconut shell is used as fuel in “coprahan” while the rest is sold at an average of 3 PHP per kg was used as the selling price. The resulting value is then added to net profit from copra to get the total profit of 15,672 PHP (348 USD) per year.

Table 4-3 Costs and returns in production of copra from one ha coconut production

ITEMS		QUANTITY	COST PER UNIT (PHP)	TOTAL (PHP)
Direct Costs	Mature Dehusked Coconut Input	6432 kg	4.50/kg	28,944
	Labour	6 m-days	300/m-day	1,800
	Trucking		300/t	600
	Sub-Total			**31,344**
Overhead	Miscellaneous (helper, fees and local taxes, selling and administrative)			1,000
	TOTAL COST			**32,344**
TOTAL OUTPUT, kg (33%)		**2122.56**		**46,696**
COST PER kg			**15.24**	
SELLING PRICE PER kg			**22 00**	
NET PROFIT			**6.76**	**14,352.32**
BY-PRODUCTS	Coconut Shell (22.4%)	1440 kg	3/kg	4320
	Less shell used as fuel	1000 kg		3000
	Sales of shell	440 kg		1320
TOTAL PROFIT			**7.38**	**15,672.32**

(3) Net Profit from Refined Coconut Oil Production

The amounts of material inputs required to process the copra produced from one ha nut production into refined coconut oil along with the corresponding costs are shown in Table 4-4. The labour requirement is one man-day with a wage rate of 350 PHP.

Total cost in processing the copra input from one ha amounts to 49,212 PHP which mostly due to the cost of copra which accounts for almost 98 percent of the total cost. Refined coconut oil is sold at 42 PHP per kg. The total amount of refined oil produced was based on 2123 kg of copra input in which 61.5% of which is crude oil and 92.5% of crude oil is refined oil. Total revenue from RBD sales is 50,724 PHP. Net profits per ha and per kg amount to 1,512 PHP and 1.25 PHP, respectively.

Revenues are also generated from the sales of by-products in oil production namely copra meal and fatty acid. The quantity of copra meal was derived by getting 32% of copra input. Copra meal is sold at 3.50 PHP per kg. Copra cake or meal is sold to feed millers. Oil refineries produce coconut fatty acid as its by-product which is sold to feed mills and sometimes exported as an ingredient in soap making. Coconut Fatty Acid (CFA) can be sold at 23.00 PHP per kg. Recovery rate of fatty acid is 4.9% from refined oil. Return from the by-product sales of copra meal and fatty acid amount to around 3,849.22 PHP.

Combined net profit from RBD and by-products amounts to 5361.56 PHP (119 USD) per ha or 4.439 PHP per kg of RBD.

Table 4-4 Costs and returns in refined coconut oil production

ITEMS		QUANTITY	COST PER UNIT (PHP)	TOTAL (PHP)
MATERIALS	Copra Input (kg)	2123	22/kg	46,706
	Phosphoric acid (0.05%)	0.653	18/kg	12
	Activated carbon (0.3%)	6.369	34.35/kg	219
	Bleaching earth (1.2%)	25.476	16.7/kg	425
LABOUR	Labour (man-days)	1 m-day	350/day	350
	Sub-Total			**47,712**
Overhead	Miscellaneous (helper, fuel, fees and local taxes, loan interest)			1,500
		PHP /kg		
TOTAL COST				**49,212**
CNO OUTPUT, kg (61.5%)		1305.65	37.69	
RBD OIL OUTPUT, kg (92.5%)		1207.72	40.75	
COST PER kg of RBD			40.75	
SELLING PRICE OF RBD			42.00	50,724
NET PROFIT			**1.25**	**1,512**
BY-PRODUCTS	Copra meal (32%)	679.36	3.5	2377.76
	Fatty acid (4.9%)	63.977	23	1471.46
	TOTAL BY-PRODUCT SALES		**3.187**	**3849.22**
TOTAL PROFIT			**4.439**	**5361.56**

(4) Net Profit from Biodiesel (CME) Production

A readily convertible material for biomass production such as refined oil undergoes *Secondary Processing,* specifically the process of esterification, to arrive at the final product which is biodiesel. Table 4-5 summarises the costs and returns incurred in producing CME from one ha nut production and per L of output. The primary input is the RBD produced from copra amounting to 1,319.91 L using the RBD density of 0.91kg/L. This accounts for almost 92 percent of the total cost. Other inputs include 191.388 L of methanol and 8.843 L of catalyst. Labour requirement is 1.33 mandays per 1000 L and overhead cost amounts to 2.00 PHP per L of CME. Total costs amount to 57,915 PHP producing 1,319.91 L of CME or 43.88 PHP per L of CME.

CME is sold at 44.00 PHP per L resulting to total revenue of 58,076.23 PHP. Net profit from CME is only 160.63 PHP or 0.12 PHP per L. However additional returns are derived from the by-products. The amounts of by-products generated by the process are 150.96 kg of glycerin and 6.64 kg of acid oil. Both glycerin and acid oil are sold at 8 PHP per kg. Total returns from by-products amount to 1,260.86 PHP per batch or 40.96 PHP per L.

With the costs and returns figures at hand, an accumulated net profit of 1.08 PHP per L was recorded and 1,421.49 PHP (31.59 USD) per batch operation.

Table 4-5 Costs and returns in CME production

ITEMS		QUANTITY	COST/UNIT (PHP)	TOTAL (PHP)
MATERIALS	RBD Oil, L (0.915 kg/L)	1319.91	42/kg or 38.43/L	50,724
	Methanol (14.5%)	191.388	19.00/L	3636.36
	Catalyst (0.67%)	8.843	34.00/L	300.68
LABOUR	Labour	1.76	350/md	614.42
Sub-Total				**55,275.77**
	Overhead Costs		2.00	2639.83
TOTAL COST				**57,915.60**
OUTPUT, L CME		1319.91		
			PHP/L	
TOTAL COST of CME			**43.878**	
SELLING PRICE of CME			**44.00**	**58,076.23**
NET PROFIT from CME			**0.122**	**160.63**
BY-PRODUCTS	Glycerin, kg (12.5%)	150.96	8/ kg	1207.72
	Acid oil, kg(0.55%)	6.64	8/ kg	53.14
	TOTAL		**0.96**	**1260.86**
TOTAL PROFIT			**1.082**	**1421.49**

(5) Total Profit for All Product Forms

Table 4-6 shows that from the 6432kg of dehusked nut produced per ha per year, the biodiesel output produced amounts to 1,329.91 L. Due to the additional activities done on the input product, the production cost of the output product increases as the product changes from 2.08 PHP per kg of nut to 43.878 PHP per L of CME.

Net profit is highest for copra and mature nut production at 15,544 PHP and 15,672.32 PHP respectively. It is lowest for CME at 1,421.49. Revenue from the by-products increases the profit by 6,430 PHP. The cumulative total profit for all product forms is almost 38,000 PHP (845 USD).

Table 4-6 Summary of net profit per unit and per ha by-product form

PRODUCT FORM	NET PROFIT (PHP)		BY-PRODUCT SALES (PHP/ha)	TOTAL PROFIT (PHP/ha)
	Per unit	Per batch (ha)		
Dehusked Nut, kg	2.42	15,544.00	0	15,544.00
Copra, kg	6.76	14,352.32	1,320.00	15,672.32
Refined Oil, kg	1.25	1,512.33	3,849.22	5,361.56
Biodiesel (CME), L	0.122	160.63	1,260.86	1,421.49
TOTAL		**31,569.29**	**6,430.08**	**37,999.37**

(6) Employment and Personnel Remuneration

Table 4-7 shows the labour requirement on per ha mature nut production up to processing into CME. Total number of labourers employed amounts to 53 mandays per ha per year valued at 13,764 PHP (305.9 USD).

Table 4-7 Annual labour requirement per ha and wages paid by-product form

PRODUCT FORM	LABOUR REQUIREMENT (in m-days)	WAGE RATE (PHP/mday)	WAGES PAID (PHP)
Dehusked Mature Nut	44	250	11,000
Copra	6	300	1,800
Refined Oil	1	350	350
Coconut Methyl Ester	1.76	350	614
TOTAL	**53**		**13,764**

(7) Tax Revenue

Tax revenue is the income generated by the government from the entities involved in each production process. However, coconut farmers are exempted from paying taxes as stipulated under the Comprehensive Agrarian Reform Program of the Philippines. Thus, no taxes are generated from the farming sector. Total tax revenue for the biomass project amounts to 7,859.38 PHP (168.65 USD) per year with copra production registering the highest tax since it also generated the highest profit on per ha basis (Table 4-8).

Table 4-8 Annual tax revenue generated by-product form

PRODUCT FORM	TOTAL PROFIT (PHP/ha)	TAX REVENUE (PHP/ha)
Dehusked Nut	15,544.00	exempted
Copra	15,672.32	5,485.31
Refined Oil	5,361.56	1,876.54
Biodiesel (CME)	1,421.49	497.52
TOTAL	**37,999.37**	**7,859.38**

(8) Foreign Trade

Foreign trade impact is measured in terms of dollar earnings from product export and dollar savings from reduced diesel imports with the presence of the biodiesel project. In the event that portions of the convertible material are both exported and consumed locally for biodiesel production, a trade-off occurs. Dollar earnings from exports will then be reduced with domestic consumption. Coconut oil is one of the top dollar earners of the country and represents the dollar earnings for the coconut industry. With the adoption of CME, a portion of the total volume of production of unrefined/unrefined oil will be dedicated to CME production. As a result, the volume of exports is lessened - dollar earnings are reduced. On the contrary, dollar savings arises from CME adoption in lieu of diesel imports. Thus, a trade-off occurs. The net effect of this trade-off can be quantified by adding the reduced dollar earnings from unrefined oil exports and the dollar savings from displaced diesel by CME.

However, due to the low volume of CME production at the provincial level, it is assumed that the net foreign exchange savings will not be significant. Moreover, the value of foregone dollar earnings from the amount of refined oil that was used for CME can just be offset by the opportunity cost of CME in terms of the value of imported fossil fuel substituted it substituted. Thus the net foreign trade effect is zero.

(9) Total Value Added (TVA)

Table 4-9 shows the summary of the TVA per product form generated from per ha production of mature nut up to processing into biodiesel or CME. The total enterprise profit amounts to 37,999 PHP with total wages paid of 13,764 PHP and generating a tax revenue of 7,859 PHP per ha per year. The total VA for all the value adding activities amounted to 59,623 PHP per ha per year with dehusked mature nut production contributing the highest amount (44.5%) followed by copra production (38.5%).

Considering that around 230,440 ha in the province of Quezon are planted to coconut, the TVA from the biodiesel industry would be 13.74 billion PHP if the mature nuts production in the province will be processed into biodiesel.

Table 4-9 Total VA per year by-product form per ha of biomass utilisation

PRODUCT FORM	TOTAL PROFIT (PHP/ha)	WAGES PAID (PHP/ha)	TAX REVENUE (PHP/ha)	TOTAL VA (PHP/ha)
Dehusked Mature Nut	15,544.00	11,000.00	exempted	26,544.00
Copra	15,672.32	1,800.00	5,485.31	22,957.63
Refined Oil	5,361.56	350.00	1,876.54	7,588.10
Biodiesel (CME)	1,421.49	614.42	497.52	2,533.44
TOTAL	**37,999.37**	**13,764.42**	**7,859.38**	**59,623.17**

4.2.1.2. India

Following the methodology described in the previous section and based upon the available data and information, through field survey and from other sources, the estimations of environmental, economic and social impacts have been obtained for Jatropha Cultivation stage (TOIL) and Oil Extraction & Biodiesel Production stages (SBTL). Thus, estimation of impacts used both primary data from the field survey of these companies and secondary data for literature.

Consolidated results of estimations, during the biodiesel production chain, are being described as follows.

(1) Net Profit from Jatropha Production

The data of TOIL have been used for various estimations during the cultivation stage. The Jatropha plantation farm is well managed with all the waste being recycled and utilised at the farm. The biomass generated at the farm is composted by vermicomposting and natural composting. Vermiculture is also one of the activities at the farm and its output is utilised for earthworm multiplication and Vermicomposting. The animal excreta is utilised by the biogas digester to generate gas which is used for cooking by the workers' families staying at the farm.

The major sources of power used at the farm are diesel and electricity. The farm has a diesel run generator, which is a necessity because of irregular power supply due to frequent power cuts in the area. Also, there is a tractor which is used for farm work and also for transportation of workers and their families. The company reported that both tractors and electric generators are run by the oil extracted at the farm itself using its own raw material i.e. oil seeds. The company does not get any incentive, support or encouragement from the government but it reported that there was no interference too.

The study shows that for cultivation of Jatropha and Pongamia, there is a gestation period of about three and six years, respectively, before the plantation starts giving economically viable yields of seeds. Thus, if only oil tree yield (in this case, Jatropha and Pongamia), is considered, unless there's an increase in the yield of seeds or increase in the price of seeds, the present revenue generated is not enough to meet the cost incurred at the farm. It is reported that the most of the ancillary activities at farm start generating revenue from the second year onwards and some of them from the first year itself. Presently the ancillary activities at the farm generate almost same revenue as sale of seeds and from fifth year onwards this revenue (from ancillary activities) may even surpass the revenue generated by sale of seeds.

The results of the economic analysis in terms of revenue generation (TVA) and profit at TOIL are given in Table 4-10. Thus, after the fifth year gross profit from the farm may be stabilized at about Rs. 1.6 million per year. The net profit per ha per year is negative in the first two years of operation as expected but the net return starts to give positive values from the third year and will reach 33,100 INR on year five per ha. The value of the by-products contributes a very significant amount to the total return from the plantation.

Table 4-10 Economic analysis (net profit) of TOIL

SN	Items	Year of Jatropha Plantation				
		1	2	3	4	5
1	Total Operating cost (in Million INR)	1.2	1.2	1.2	1.2	1.2
2	Yield of Seeds in kg per ha (seeds @ 2 kg per plant yr with 1110 plants/ha from 3rd yr onwards)	0	0	2220	2220	2220
3	Total income per ha per yr (sale of seeds @ 14 INR per kg)	0	0	31,080	31,080	31,080
4	Gross Revenue (in Million INR)					
	Gross Revenue (from main products)	0	0	1.509	1.509	1.509
	Gross Revenue (from by-products)	0	0.5	0.6	1.200	1.300
5	Total Gross Revenue (in Million INR)	0.00	0.5	2.109	2.709	2.809
6	Net Profit (Revenue-Total Cost) (in Million INR)	-1.20	- 0.70	0.909	1.509	1.609
7	Annual Net Profit per ha per year (in INR)	-24,700	-14,400	18,700	31,000	33,000

Employment generation at TOIL is shown in Table 4-11. The job creation by the company is 248 person days per ha per year. Additional employment is generated through ancillary activities, which is reported to be about half of the regular employment in person days per ha per year.

Although this is not very efficient for the company but keeping in view that agriculture activities are labour intensive and social angle of generating rural employment, job creation by the company is quite impressive.

Table 4-11 Job creation per ha per year at TOIL

SN	Item	Values
1	Total Production (seeds in kg per ha per year)	2220
2	Person days per year	248

(2) Biodiesel Production Stage

Southern Online Biotechnologies Limited is the company is involved in both Oil Extraction and Biodiesel Production Stages. Due to shortage of supply of oil seeds, the company is using various feedstocks in the production process. Assuming use of Jatropha and other oil seeds as only feedstock and plant efficiency as 100%, the results of production of biodiesel stage are analysed in Table 4-12. The company reported an investment of 330 million INR, and hence, per year TVA of 519.7 million INR and a profit of 278.7 million INR is quite impressive.

Table 4-12 Economic analysis of biodiesel production of SBTL

SN	Items	Values
1	Biodiesel Production capacity/day (L)	40,000
2	Annual Production Capacity (L)	14,600,000
3	Raw Material (RM) Requirement/yr (kg): @2200 kg/ha yield the total land area needed is 5707 ha	12,556,000
4	Cost of RM @ 16 INR/kg	200,896,000
5	Production Cost without RM (@2.75 INR/L)	40,150,000
6	Gross Revenue (from main product) – @ 33/L Selling Price	481,800,000
7	Gross Revenue (from by-products (glycerine & 26 INR/kg)	37,960,000
8	Total Gross Revenue in INR	519,760,000
9	Net Profit (Gross Revenue-Total Cost) in INR	278,714,000
10	Net Profit per ha per year in INR	48,837

Comparing the biodiesel production stage with the plantation stage indicates that productivity is much higher in the biodiesel production stage at 48,873 INR against 33,000 INR in the plantation. This is true for all agricultural activities when compared with manufacturing sector. The employment generated per L of biodiesel produced at

SBTL is 0.002 person day per L of biodiesel produced (Table 4-13).

Table 4-13 Job creation per unit of biodiesel prodcution at SBTL

SN	Items	Values
1	Total Production (L)	14600000
2	Person days (110x365)	40150
3	Employment per unit yield (in person days)	0.00275

The impact on foreign trade (forex savings) by the SBTL is as shown in Table 4-14. It indicates a positive impact on foreign trade as the savings of 9.18 million USD per year are quite significant.

Table 4-14 Impact on foreign trade by SBTL

SN	Items	Values
1	Bio-diesel production per year	14600000
2	Above in terms of barrels	122442.13
3	Foreign exchange saved @ 75 USD/barrel	9183160.01

1barrel (US liquid) = 119.24 L

4.2.1.3. Indonesia

The production of cassava by the farmers is either through individual farming or partnership farming. In the partnership farming, the farmer members do the farming activities such as land preparation as one group and they share the cost incurred equitably.

(1) Net Profit from Cassava Production

Cassava farming shows to be an attractive business for the farmers as shown by the 44.98% and 49.74% return for non partnership and partnership farming options respectively. Farmers engaged in partnership farming got significantly higher benefit than that of non partnership farmers. This is brought about by the lower land preparation cost (machinery rental) and higher production volume of 28,490 kg/ha compared to 24,670 kg/ha for non partnership farming. This is brought about by better land preparation in partnership farming. This was likely resulted from land quality which is implied by its tax cost. The higher cost for land preparation (machinery rent) as well as manpower for non partnership farmers also reflected that the land quality is lower than that of partnership farmers. Refraction, which is 0-5% penalty due to starch content, is another important factor. Refraction for non partnership farmers (945,628 IDR/ha) was considerably higher than that of partnership farmers (626,807 IDR/ha). This might be resulted from either their low quality cassava roots or a particular policy acted for non partnership farmers so that they received higher refraction.

Table 4-15 Costs and returns in cassava production for partnership farmers

ITEMS		**QUANTITY (/ ha)**	**COST/UNIT (in IDR)**	**COST/ha (in IDR)**
MATERIAL	Seed, Fertilizer, compost, and Chemicals	1 package	1,187,950	1,187,950
LABOUR	Weeding, Fertilizing, and Other Maintenance	28.05 days	25,000	701,328
MACHINE	Land preparation	1 package	294,498	294,498
	Harvesting and Transportation	28.49 t	69,545	1,981,338
OVERHEAD	Tax, and rent, refraction			2,135,280
TOTAL COST				**6,300,394**
TOTAL fresh cassava root		**28,490 kg**	**439.25**	**12,536,138**
NET PROFIT				**6,235,744**

The most important factor affecting farmers' benefit is cassava price. In the analysis, the price of cassava tuber for partnership farmers was 439.25 IDR/kg (Table 4-15) and it was not significantly different to that of non partnership farmers at 449.75 IDR/kg (Table 4-16). It was about the normal price for cassava roots. In conclusion it can be wrapped up that cassava cultivation for partnership farmers is a better economic activity than that of non partnership farmers.

Table 4-16 Costs and returns in cassava production for non-partnership farmers

ITEMS		QUANTITY (/ ha)	COST/UNIT (in IDR)	COST/ha (in IDR)
MATERIAL	Seed, Fertilizer, compost, and Chemicals	1 package	1,027,716	1,027,716
LABOUR	Weeding, Fertilizing, and Other Maintenance	37.31 days	25,000	832,811
MACHINE	Land preparation	1 package	478,172	478,172
	Harvesting and Transportation	24.67 t	74,897	1,847,716
OVERHEAD	Tax, and rent, refraction			1,823,862
TOTAL COST				**6,110,277**
TOTAL fresh cassava root		**24,670 kg**	**449.75**	**11,106,193**
NET PROFIT				**4,995,916**

(2) Net Profit from Bioethanol Production

The cassava roots are transported to the ethanol factory after harvesting. Cassava is processed at ethanol factory through several processes, such as washing, rasping, liquefaction, saccharification, fermentation, and distillation. Besides bio-ethanol as main product, the ethanol factory also produced wet cake, cassava peels, some soil as solid waste, and thin slop that is high concentration of organic matter. The solid wastes can be utilised as a raw material to produce compost. The factory collaborates with third parties to handle these solid wastes and producing compost.

Processing cassava into ethanol is expected to bring about VA for cassava farming. About 6.48 kg of fresh cassava is needed to produce one L of ethanol. At investment cost for ethanol plant is 45 million US dollar and ethanol production cost is estimated at 150-160 USD/kL ethanol or 15 to 16 cent per L excluding raw material (cassava). At cassava price of 439.25 - 449.75 IDR/kg and exchange rate of 9200 IDR a dollar, the total cost of ethanol production will be in the range of 4231 to 4388 IDR per L. Currently, ethanol price is 580 USD/kL ethanol or 5336 IDR/L. The VA resulted from ethanol processing was 950-1108 for every L ethanol being produced. In other word, ethanol processing has resulted in VA of 147-171 IDR per kg of cassava. Figure 4-1 shows the VA resulted due to ethanol processing from cassava tubers. Table 4-17 shows a net profit of 4,934,930 IDR coming from the sales of ethanol and an additional 3,949,400 IDR coming from the biogas and compost produced as by-products.

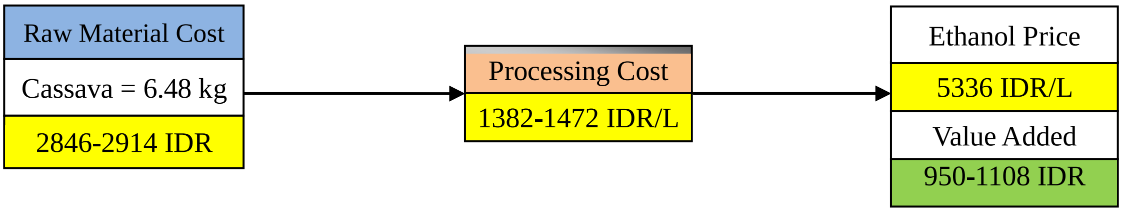

Figure 4-1 VA resulted from processing cassava tubers into ethanol on per L ethanol basis

Table 4-17 Costs and returns in production of ethanol from one ha cassava production

ITEMS		QUANTITY	COST/UNIT (IDR)	TOTAL (IDR)
TOTAL COST		4,466 L	4,231	18,895,646
TOTAL OUTPUT, L		4,466 L	5,336	23,830,576
SELLING PRICE PER L			5,336	
NET PROFIT				4,934,930
BY-PRODUCTS	Biogas	712 m^3	4,200	2,990,400
	Compost	1.37 t	700,000	959,000
ADDITIONAL PROFIT				3,949,400
TOTAL PROFIT				8,884,330

The high price of cassava roots is attributed to tough competition for cassava in the market brought about by demand from the food and nonfood industries. This condition is good for farmers as they will get increased benefit by 13,443,992 IDR/ha and 10,014,104 IDR/ha for partnership and non partnership farmers, respectively. Nevertheless, it is difficult situation for ethanol plant because the high cassava price resulted in a much higher production cost. The structure of production cost of ethanol from cassava shows that more than 65% is attributed to raw material (cassava tubes) cost.

The utilisation of ethanol for biofuel needs additional process to remove the remaining water. The fuel grade bio-ethanol will have price higher than 580 USD/kL ethanol or 5336 IDR/L. It is difficult to utilise bioethanol as a biofuel in Indonesia because until now gasoline price is still subsidized by the government. The subsidized price for gasoline (premium) is 4500 IDR, much cheaper than bioethanol prices and almost similar with production cost. Subsidy system should be adopted on bioethanol production if Indonesia wants to implement bioethanol as a biofuel mixed with premium. Enforcement from government is really needed to utilise bioethanol as a biofuel.

(3) Net Profit from Jatropha Production

Jatropha is developed under a concept called Desa Mandiri Energi or Self-Sufficient Energy Village (SSEV). The SSEV pilot project was sponsored by Eka Tjipta Foundation in Way Isem, North Lampung as a manifestation of Corporate Social Responsibility from Sinar Mas group.

The foundation provided 100 kg seed for the whole community or 0.8 kg for each family. The villagers collect and peel Jatropha nuts, and then sell the seeds to the Koperasi at a price of 1000 IDR/kg seed. Jatropha seed is processed by the "Koperasi" to produce Jatropha oil (CJO) and the oil is used to run generator set for electricity production. All the processing equipment like generator set, Jatropha mill, oil filter and degummer have been provided by Eka Tjipta. To produce 1 L CJO requires 3.3 kg of Jatropha seed. The CJO is sold to Eka Tjipta at a price of 10.000 IDR/L. Therefore, the Koperasi gets 4000 IDR gross profit that is used to pay the cost for Jatropha processing and to run the Koperasi. Small part of the profit will be returned to the Koperasi members as dividend.

Later on, the foundation also provided 20 units of anaerobic digester to produce biogas fuel from the Jatropha cake. Other biomass waste from peeling and pruning is returned back to the field as compost.

Table 4-18 showed the economic evaluation for Jatropha production. It shows that the production of Jatropha seeds alone is not profitable. According to the Village Head, Jatropha farming is not profitable because the selling price of Jatropha seed at 1000 IDR/kg is too cheap. The farmer will benefit more by working as labourer (where the daily wage is 30,000 IDR) than planting Jatropha. Other than that, they find Jatropha cultivation to be laborious. Furthermore, the nuts have to be peeled before it is handed to the cooperation. So far, removing the peel is laborious and is conducted manually. These problems have decreased the attraction of Jatropha to the "Koperasi".

Table 4-18 Costs and returns in Jatropha seed production

ITEMS		QUANTITY/ ha	COST/UNIT (in IDR)	COST/ha (in IDR)
MATERIAL	Seed, Fertilizer and Other Chemicals, Compost	1 package		214,648
LABOUR	Land preparation, planting, Fertilizing, and Other Maintenance	64.11 day	24011	1,539,345
	Harvesting, peeling and Hauling	26.92 day	24011	646,376
TOTAL COST				2,400,369
TOTAL SEED		790 kg	1,000	790,000
NET PROFIT				-1,610,369

The Village Head has proposed to Eka Tjipta to also provide a mechanical 'fruit peeler' to the Koperasi that will reduce the manual work required to peel the Jatropha nuts. He expected that a worker working with mechanical peeler would produce at least 50 kg seed. Simple mechanization of removing the skin of the fruits was seen as the only way to make the Jatropha planting a feasible economic activity.

(4) Net Profit from Jatropha Oil Production

Processing Jatropha into CJO is expected to result in VA for Jatropha production. Every 5 kg of Jatropha nuts was peeled to produce a kg of Jatropha seeds. The seeds then were processed into CJO and three kg of Jatropha seed is needed to produce one L CJO. It was observed that CJO production cost was about 1000 IDR/L CJO excluding the cost of raw material (seeds). Currently, CJO is sold a price of 10,000 IDR/L. The VA resulted from CJO processing was 1000 IDR/kg seed (Figure 4-2).

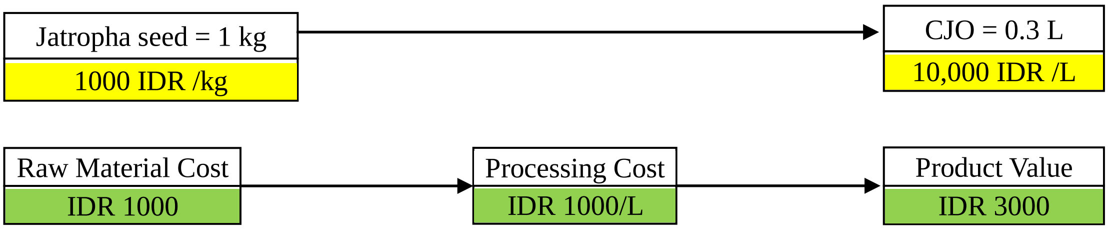

Figure 4-2 VA resulted from processing Jatropha seeds into CJO on a kg seed basis

Economic benefit of Jatropha production can be optimized by using all Jatropha waste such as Jatropha cake to produce biogas and Jatropha peel, wet cake, and sludge for compost. Assuming the price for simple organic fertilizer is around 700 IDR/kg, calculation on per ha basis revealed a significant additional economic benefit from the utilisation of waste.

With CJO yield of 239.4 L/ha and CJO price of 10,000 IDR, it can be showed that total revenue will be 4,781,938 IDR/ha. Therefore, the economic benefit is improved to 1,453,569 IDR (Table 4-19). This was not a bad economic activity given that Jatropha is planted as intercropping.

Table 4-19 Costs and returns in production of CJO from one ha Jatropha production considering a maximum use of waste

ITEMS		**QUANTITY**	**COST/ UNIT (IDR)**	**TOTAL (IDR)**
Direct Costs	Seed input cost	790 kg	1,000/kg	790,000
	Labour cost	790 kg	1,000/kg	790,000
	Fuel	27.6 L	5,000/L	138,000
	Sub-Total			1,718,000
Overhead	Miscellaneous (helper, fees and local taxes, selling and administrative)			0
TOTAL COST				1,718,000
TOTAL OUTPUT, L CJO		239.4	10,000	2,394,000
NET PROFIT				676,000
BY-PRODUCTS	Jatropha peel (0.4 factor)	1264 kg	700	884,800
	Biogas from Jatropha cake*	275.3 m^3	4200	1,156,260
	Solid/sludge fertilizer	550.6 kg	630	346,878
ADDITIONAL PROFIT				2,387,938
TOTAL PROFIT (IDR/ha) from processing				3,063,938
TOTAL PROFIT (IDR/ha) from farming and processing				1,453,569

**) 1 m^3 biogas is equivalent to 0.6 L kerosene*

Another way that could possibly increase the interest of the people is to install more biogas digester. The idea is that the Koperasi will return back the Jatropha cake for free to the people only when the people bring Jatropha seed to the "Koperasi".

Based on the observation, it is strongly recommended that Jatropha has to be cultivated as intercrop plant. In fact, company such as Wellable Indonesia suggested that Jatropha should be planted only for extra earning through mix or intercropping with other main crops. It is also important to reorient the people about their perception on Jatropha cultivation in particular and SSEV in general. So far, the people have already been fulfilled with a high expectation on Jatropha. It should be pointed out that by planting Jatropha as merely an additional activity the community is able to produce bioenergy for itself without any reduction on the income.

4.2.1.4. Thailand

For economic assessment, four factors are taken into consideration, namely, total net profit, wages (employment), tax revenues and foreign trade earnings. These factors are investigated at the level of the sugarcane plantation and the biorefinery complex. From this information TVA is calculated for each level and for the whole complex (sugarcane plantation plus biorefinery complex).

Based on annual sugarcane production, total net profit is calculated for the sugarcane plantation and the biorefinery complex. For taxes, the tax rate is defined at 0.75% as withholding tax. For the biorefinery complex, annual net profit was collected from annual report. Net profit is calculated by deducting total income (total revenues from operations and other incomes) with corporate income tax at 35% and total costs and expenses.

Tax revenue for this study includes sugarcane plantation from the farmers who are selling their sugarcane to the biorefinery complex and from the biorefinery complex itself. However, it is important to point out that in Thailand alcohol factory producing ethanol and fertilizer and biomass power plant are exempted from paying taxes for a certain number of tear which is applicable for this pilot study. Therefore, taxes are only coming from the production stage of sugarcane and the sugar mill. As reported earlier, for the sugarcane plantation there is a withholding tax of 0.75%, while for the biorefinery complex there is a corporate income tax of 35%.

(1) Economic impact of the sugarcane plantation and biorefinery complex

For the economic assessment of the biorefinery complex, including sugarcane plantation, TVA was calculated both for the sugarcane plantation and the biorefinery complex.

The first factor is total net profit. Based on the annual amount of sugarcane required by the biorefinery complex 1,872,981 tonne/yr with a production yield 1,000 kg/0.1 rai, the total area of sugarcane cultivated is 187,931 rai/yr. The average cost for sugarcane farming is approximately 7,500 THB/rai, therefore, the annual cost for the whole area amounts to 1,423,110,604 THB including material cost and overhead cost, and the annual gross revenue is 1,816,792,036 THB. The net profit from sugarcane plantation amounts to 393,681,432 THB. Data for sugarcane plantation was collected via interview and questionnaire surveys.

For the biorefinery complex, costs of materials plus overheads for sugar production, electricity generation, ethanol production, and fertilizer production amount to 11,113,781,852 THB/yr. The annual revenue is 12,070,494,453 THB. Hence the net profit for the biorefinery complex amounts to 956,712,601 THB.

The total annual net profit for the whole biorefinery complex, including sugarcane, is 1,350,394,033 THB. Financial data for the biorefinery complex were extracted from the annual report. The results are presented in Table 4-20.

The second factor is wages (salaries paid). This factor is defined based on the annual labour requirement for sugarcane plantation and biorefinery complex. Wages paid for the sugarcane plantation is based on provincial standard wages amounting to 157 THB/persons/day. The labour requirement is around 15,035 persons/yr. Thus annual wages paid are about 708,125,095 THB for the sugarcane plantation.

For the biorefinery complex, labour requirement is divided into two periods: production period and normal period. The biorefinery complex requires 3,142 of permanent labour over a whole year and requires additional labour force during the production period (120 days), about 2,253 of temporary labour. Therefore annual wages paid for the biorefinery complex are approximately 760,810,000 THB. Consequently, the total amount of annual wages paid for the bioenergy complex, including sugarcane plantation, amounts to 1,468,935,095 THB for a total of 5,723,311 man-days (see Table 4-21).

The third factor is tax revenue. This factor is subtracted from total income from the sugar plantation and biorefinery complex. The tax rate (withholding tax) for the sugar plantation is 0.75% of total income. The total income from selling 1,872,981.48 tonnes cane/yr at 970 THB/tonne cane is 1,816,792,035.60 THB/yr; accordingly, the annual tax paid is 13,625,940 THB. For the biorefinery complex, the annual tax paid is 357,494,554 THB which corresponds to 35% of corporate income tax. The results regarding total profit before tax for both the sugarcane plantation and the biorefinery complex are also reported in Table 4-22 along with their corresponding Tax revenue.

Table 4-20 Annual cost and returns for plantation and biorefinery in Khon Kaen

PLANTATION		**QUANTITY**	**COST/UNIT (THB)**	**COST/TOTAL AREA (RAI) (THB)**
MATERIAL	Seedling and planting materials Fertilizer, Pesticides and Other Chemicals		7,500/rai	1,423,110,604
OVERHEAD	Transportation/ Delivery Cost, Tax			
TOTAL COST				1,423,110,604
				REVENUE/TOTAL AREA (RAI) (THB)
TOTAL GROSS REVENUE (From sugarcane plantation)		1,872,981 t/yr	970/t	1,816,792,036
SUB-NET ROFIT				393,681,432
BIOREFINERY COMPLEX IN KHON KAEN				COST/YR (THB)
MATERIAL	Total cost of operation			8,680,081,437
OVERHEAD	Miscellaneous (Financial cost, selling and administrative expenses, fee, tax, etc.)			2,433,700,415
TOTAL COST				11,113,781,852
				TOTAL/YR (THB)
TOTAL REVENUES from Operation (From sugar, electricity, ethanol and fertilizer)				11,688,514,083
OTHER INCOMES (Dividends income, profit sharing, etc.)				381,980,370
SUB-NET ROFIT				956,712,601
TOTAL NET PROFIT				1,350,394,033

Remark: 1 rai = 0.16 ha

Table 4-21 Annual labour requirement and wages paid by-product form

PRODUCT FORM	LABOUR REQUIREMENT (m-days/per total area (rai)-year)	WAGE RATE (THB/m-day)	WAGES PAID (THB/yr)
Sugarcane (plantation)			
Land preparation Planting Fertilization Weeding	4,510,351	157	708,125,095
Biorefinery complex			
Production season period	270,360	-	760,810,000
Normal period	942,600		
TOTAL	**5,723,311**		**1,468,935,095**

Table 4-22 Annual tax revenue generated by-product form

PRODUCT FORM	TOTAL PROFIT (THB-year)	TAX REVENUE (THB-year)
Sugarcane (plantation)	407,307,372	13,625,940
Biorefinery complex in Khon Kaen		
Sugar (Sugar Factory) Electricity (Biomass Power Plant) Ethanol + Fertilizer (Alcohol Factory)	1,314,207,155	357,494,554
TOTAL	**1,721,514,527**	**371,120,494**

The last factor is foreign exchange earning. This factor is considered by mean of substitution of gasoline with ethanol. Due to the lower heating value of ethanol (100%) as compared to gasoline, the substitution ratio of gasoline with ethanol is 1: 1.56 L (Table 4-23).

Table 4-23 Substitution ratio for gasoline with ethanol

Fuels	Specific gravity*	Avg. Density (kg/m^3)	Lower heating value* (MJ/kg)	Lower heating value* (MJ/m^3)	Lower heating value* (MJ/L)	Ratio (L)	Price** (THB/L)
Gasoline	0.75	750	44	33,000	33	1.00	19.30
Ethanol	0.785	785	26.9	21,116.5	21.12	1.56	

*Remark: * Heywood, 1988 ** DEDE, 2010*

Thus, the amount of ethanol produced by the Alcohol factory is 42,510,380 L/yr. From this amount, the corresponding amount of gasoline that is displaced by ethanol is 27,202,135 L/yr. This translates in a saving from avoid importation of gasoline amounting to 525,008,930 THB/yr (Table 4-24).

Table 4-24 Annual foreign exchange earnings from substituting imported gasoline by ethanol

PRODUCT FORM	QUANTITY (L/yr)	COST PER UNIT (THB/L)	TOTAL COST (THB/yr)
Ethanol produced by the Alcohol factory	42,510,380		
Gasoline substituted by Ethanol	27,202,134.52*	19.30	525,008,930
TOTAL			525,008,930

*Remark: *Substitution ratio at 1 L of gasoline: 1.56 L of Ethanol (based on energy content)*

All financial parameters detailed above are summarised in Table 4.2-23 and the total VA for the bioenergy complex including the sugarcane plantation amounts to 3,715,458,551 THB for a year.

Table 4-25 shows the summary of the TVA per product form generated from the per ha production of sugarcane to processing into bioethanol. The total enterprise profit amounts to 44,909.90 THB with total wages paid of 48,852.21 THB, tax revenue of 12,342.30 THB and foreign exchange of 17,460.16 THB per ha per year. The TVA for all the value adding activities amounted to 106,104.41THB per ha per year.

Table 4-25 Total Value Added per year from biomass

ECONOMIC ASSESSMENT	PRODUCT FORM		TOTAL VA (THB/yr)
	Plantation (THB/yr)	Khon Kaen Biorefinery Complex (THB/yr)	
Total Net Profit	13,096.9	31,815,2	44,909.90
Wages Paid	23,550.04	25,302.17	48,852.21
Tax Revenue	453.15	11,889.16	12,342.30
TVA			106,104.41

4.2.2. Highlights of Pilot Studies from Economic Aspect

4.2.2.1. Total Net Profit

All the biomass projects from the four pilot studies evaluated showed positive total net profit. It means that business side of the biofuel projects evaluated is attractive both in the plantation and processing of biofuel feedstock to biodiesel or bioethanol except in the plantation of Jatropha in a small village in Lampung, Indonesia. The biofuel projects in Philippines, India, Thailand and even the biethanol production in Lampung, Indonesia are all medium scale projects unlike the very small Jatropha production and processing in Way Isem village in Lampung, Indonesia. The low price of Jatropha seed paid to the farmers makes the plantation economically unattractive. However, processing of biofuel feedstocks in all the biofuel projects make the business profitable particularly with the economic value of the by-products.

The profitability of biofuel project will improve if the processing plant is assured of the availability of raw material for processing and it may be protected from the possible fluctuation in the price of raw material. In the case of the Philippines, the attractiveness of coconut oil production is dependent on the price of copra which affects the price of its product, coconut oil which is the raw material in the biodiesel production. The profitability of bioethanol in Indonesia and Thailand is highly dependent on the prices of cassava and sugarcane in Indonesia and Thailand respectively. The profitability is also enhanced with the profit from the sale or utilisation of by-products both in the plantation and processing plant. Sales of coconut shell in the case of Philippines, production of biogas from Jatropha and cassava in Indonesia, utilisation of oil cake and glycerol from Jatropha in India and electric power produced from bagasse and the use of waste material from the production of bioethanol in Thailand contributed to the increased profitability of the biofuel projects.

4.2.2.2. Wages (Salaries Paid) and Tax Revenue

Production of biofuels provides substantial wages both in the production and processing aspects of biofuels. In the Philippines the total wage is 13,674 PHP or 305

USD per ha per year while Thailand has much higher wage at THB 48,852 or 1526 USD per ha per year. Wages in the case of the Philippines is much higher at the plantation than copra, oil and CME plants on per ha per year basis. This is so because coconut plantation is mostly manual hence labour intensive. Wages is almost the same in the sugarcane plantation and biorefinery complex are almost the same since sugarcane plantation is normally mechanized.

In the case of taxes generated from the wages of personnel and profit of the processing plants, The total taxes generated in case of the Philippines is 7,859.38 PHP or 174 USD per ha per year and 7,859 TBH or 174 USD per ha per year in Thailand. Most of the taxes are generated in the processing plants than in the plantation. This is so because farmers are normally exempted from taxes as in the case of the Philippines or the taxes is very minimal as in the case of Thailand which is 0.75% of the total income in the plantation compared to 35% imposed in the biorefinery.

4.2.2.3. Foreign Trade Earnings

The impact on foreign trade (forex savings) indicates a positive impact on foreign trade as seen from the biodiesel project in India and ethanol project in Thailand. Southern online Bio Technologies Limited (SBTL) in India provides foreign trade savings of 9.18 million USD per year or 1,609 USD per ha per year while Khon Kaen Biorefinery complex produces 42,510,380 L of ethanol which can displaced 27,202,135 L of gasoline per year. This translates to 16,406,529 USD or 545.6 USD per ha per year.

4.2.2.4. Total Value Added

Biofuel projects evaluated showed a positive overall value added as shown in the biodiesel project in Quezon, Philippines and ethanol project in Khon Kaen, Thailand. The TVA in the production of ethanol from sugarcane in Thailand is 123,564.57 THB or 3,861.39 USD per ha per year while the biodiesel production from coconut in the Philippines showed a TVA of 59,623.17 PHP or 1,324.90 USD per ha per year.

4.2.1.5. Conclusion

The economic indicators used for evaluating the economic impact of the biofuel projects in the pilot studies are appropriate. Sustainable utilisation of biomass for biofuel production can generate economic gains for various players of the biomass industry. Raw material or biofuel feedstock production will give the grower (farmers) decent income while processing to biodiesel will provide positive value added for local manufacturers or processors. Production of biofuels creates employment resulting in wages for the employees and net profit for the business, hence, contributes to taxes generated by the local government. It can also displace imported fossil fuel resulting in foreign exchange savings for the country.

The total net profit derived from the production and processing of biofuel feedstocks plays a very important role in the sustainable production of biofuels. Positive economic returns will encourage the business to continue. Sufficient and reasonable wages received by the employees will encourage them to perform their functions well contributing to the success of the business. At the same time, taxes paid by both the employees and the company will provide additional revenue to the government. This tax revenue and the net dollar savings by the government will encourage the country to provide support to the biofuel business contributing to the sustainable production and use of biofuels.

4.3. Social Aspects

For social impact assessment, the Human Development Index (HDI), developed by the UNDP, was proposed as the main indicator in all four country studies. HDI essentially measures three important social factors, viz., life expectancy at birth, as an index of population, health and longevity; adult literacy rate (with two-thirds weighting) and the combined primary, secondary, and tertiary gross enrolment ratio (with one-third weighting); and the gross domestic product (GDP) per capita at purchasing power parity (PPP) in USD.

The objective of selecting HDI was to give a glimpse of the living standards of the people currently engaged in biofuel production. However, as there is a significant difference in social set up of each country selected for the pilot studies, in addition to HDI, other social development indicators (SDIs) were also considered, which may reflect some country specific social issues. During the field survey it was observed that level of biofuel development in each of the four pilot study countries was quite different. Some noticeable inferences could be made from the results and this sub-section highlights such observations from the case studies.

4.3.1. Findings from the Four Pilot Projects

In general, the social impact assessment using HDI as the main indicator gave satisfactory results. However, some minor modifications in the questionnaire were required to capture some country specific factors such as feedstock, research and development, policies on biofuels, etc. HDI estimates, albeit not updated periodically, are available up to district level in some countries but for most countries they are available only at provincial or state level. It is important to compare the change in social welfare as a result of activities related to biofuel production. Ideally, such comparison should be made between the actual situation "before and after" the activity but data and information for "before and after" scenarios were not available. As biofuel production in all countries selected in the project is at its initial stage, data availability on various aspects of sustainability was a major problem.

Due to the above limitation, some case studies compared the estimated HDI values of the case study location with the prevailing HDI in the region while others compared it with either the provincial or national HDI. In cases where the comparison is not from "actual before and after scenarios," most people engaged in biofuel production related activities also have other means of livelihood so the positive change in HDI calculated in the pilot projects could not be solely attributed to biofuel production. In some case studies, a negative change in HDI was observed, which indicates that the respondents still live below the average living standards in that region in spite of economic gains they received after engaging in biofuel production. Gender-related Development Index (GDI) was also calculated and expressed as certain percentage of HDI, which reflects inequalities between men and women in all countries.

The findings from the four pilot studies are summarised as follows and estimated values of HDI and GDI for each country are listed in Table 4-26.

Table 4-26 Social development indicators due to biofuel production in various countries

Social Development Indicator	Country			
	India	**Indonesia**	**Philippines**	**Thailand**
HDI (for Study Site)	0.616	0.398 (Way Isem, Jatropha) 0.541 (North Lampung, Cassava)	0.785	0.736 (Sugarcane Plantation) 0.797 (Bioenergy Production)
HDI (for country, as per UNDP)	0.612 (AP)	0.694 (North Lampung)	0.771 (Quezon)	0.763 (Khon Kaen)
Change in HDI	0.004	- 0.296 (Way Isem, Jatropha) -0.153 (North Lampung, Cassava)	0.014	- 0.027 (Sugarcane Plantation) + 0.034 (Bioenergy Production)
GDI (for Study Site)	0.604	0.3494 (Way Isem, Jatropha) 0.5351 (North Lampung, Cassava)	0.784	0.734 (Sugarcane Plantation) 0.795 (Bioenergy Production)

4.3.1.1. India

The HDI values were estimated for both Jatropha cultivation and biodiesel production stages. Since both of these activities were newly established in the study region, it was possible to get the change in economic and employment status before and after the facilities. A positive and average change of 0.004 in HDI was observed in both stages indicating an overall social development of the affected population around the study location. The GDI value for both stages was observed as about 98.2% of the HDI value indicating a minor difference in social development of men and women workers involved in biofuel production. Some other country specific SDIs such as Living Standard, Change in Literacy, Change in Female Literacy, Change in Pucca Dwellings, etc, showed a positive change in overall social improvement due to establishment of the biodiesel production activities in the region.

4.3.1.2. Indonesia

Indonesian study focused on two different feedstocks and biofuels, namely, Jatropha oil for production of biodiesel in Way Isem village and Cassava roots as feedstock for ethanol production in North Lampung. Primary data used for calculating HDI were obtained from the field survey and secondary data in the case of Jatropha were available at village level but for cassava they were available at district level. In comparison to HDI value of 0.694 for North Lampung, the HDI values for Jatropha and Cassava cultivation sites were found to be very low. For Jatropha based biodiesel production an HDI of 0.398 showed a negative change of (-0.296) and for Cassava based ethanol production an HDI of 0.541 showed a negative change of (-0.153). Thus, farmers engaged in both planting Jatropha and Cassava has a lower living standard and an overall social development than the North Lampung. A high mortality rate was observed in Way Isem with high incidences of infant deaths making the average life expectancy of only 31 years. Farmers surveyed in both cases have a very low income and make their both ends meet with an earning of lesser than two USD per day.

4.3.1.3. Philippines

In the Philippines study, estimation of HDI was carried out using primary data from the field survey and secondary data from other sources. As district level data was not available, provincial level data was used to calculate the HDI for the pilot project site. The change in HDI was found by subtracting the current HDI for the Philippines from the estimated HDI for the Quezon due to biodiesel production. The change in HDI was found to be 0.014 indicating improvement in social development at the study site, which may be attributed to the activities related to the biodiesel production. An estimated GDI value for Quezon is 0.784, which is almost equal to the value of HDI. This means that there is a better equality between male and female workers engaged in biofuel production in the Quezon province.

4.3.1.4. Thailand

Pilot study of Thailand focused on two biofuel-related activities, namely, sugarcane plantation and bioenergy production. Hence, the values of HDI for both of these activities were estimated using primary data from the field survey and secondary data from elsewhere. GDP index is taken from the survey results while life expectancy index and education index are obtained from Thailand national statistics data. The change in HDI for Khon Kaen was found to be negative for plantation stage (-0.027) but it was positive for bioenergy production stage (0.034). Thus, the HDI of employees working at the bio-refinery complex is higher than the average HDI for Khon Kaen. But the farmers working in sugarcane plantations have lower HDI than the average HDI for Khon Kaen. However, this may be due to the reason that parameters for life expectancy and education index were held constant, as data were not available, and income is the main variable affecting the estimated HDI results.

While the bio-refinery complex in Khon Kaen enabled its employees and sugarcane farmers in the area to have a steady income opportunity translating into improved living standards, it can be inferred, based on the HDI results, that farmers need more assistance to improve their yield thereby increasing their income or find other ways to augment their income to be at least at par with the standard of living of average people in Khon Kaen.

4.3.2. Highlights of Pilot Studies from Social Aspects

During the field surveys it was found that in addition to HDI and GDI, as determinants of social development, some other social parameters are also important in assessing the overall social impact of bioenergy development. This sub-section highlights the findings of the pilot studies and also suggests improvement in the questionnaire, field testing process and data gathering in the survey process and utilisation of the information gathered to analyse social impacts of biofuel production chain.

- In most countries, the government policies are encouraging the biofuel development. Employment generation and better income opportunities for the rural population are major social aspects, which are being considered in biofuel production.

- As food need of the growing population in all countries is more important than biofuel development, it is necessary that enough safeguards are in place. It was observed that governments are careful about the "food versus fuel competition". For example, in India, national policy on biodiesel production focuses on use of waste lands for cultivation of Jatropha and other non-edible tree oils.
- Studies observed that it was difficult to convince farmers to take up the biofuel plantation as it was not economically viable for them. One way to encourage them is to explore the potential to link biofuel plantation, which depends on energy crop planted, with afforestation measures to be able to assign CER benefits to plantation resulting in an increase in their income. Other possibility is to provide them financial help to initiate some ancillary activities along with biofuel crops so that they are able to survive during gestation (non-yield) period.
- Recognizing the different levels of development of biofuel industry in the four pilot study countries, size of enterprises surveyed, and varying roles of stakeholders interviewed, the same set of questionnaire used for the four pilot studies could capture the factors affecting the estimation of HDI, the main indicator of the social impact assessment.
- Other information needed to measure life expectancy, education index and GDP index can be obtained from government statistics office. The level of data availability varies in different countries. In most cases, Provincial data are available and in some cases even district level data are available but town or village level data are not available in any country, and therefore, comparison of HDI and other SDIs becomes difficult.
- HDI is a comprehensive measure of social development, which is more valuable in macro scale planning. Other SDIs are difficult to quantify, and therefore, face to face interviews are necessary to gauge local nuances not captured in identified parameters of social impact.

- Both direct and indirect social impacts were observed, although not measured, during the surveys. For example, Way Isem village (Indonesia), women felt empowered to earn a side income and they were proud to be involved in an initiative, the government's ESSV project, which extends beyond their village. Similarly, the change in HDI among farmers at Jatropha plantation of TOIL farms (India) may not be that significant but from personal interviews, it was noted that the opportunity to send their children to school was one of the benefits they cited after getting engaged in the farm. Such issues are important aspects of social assessment of biofuel production and should be considered.
- Additional social indices relevant at community level should be added even if it may not be quantified. For example, although Thailand study found a negative change in HDI for the sugarcane plantation but still framers involved in the process felt happy as their link with the sugar mill was more or less certain and annual income secured. Some other SDIs at community level could be increased income of the employee, better education for the children, improved health condition and probably improved relationship in the plant or community, among others.
- Establishment of baseline data, both at micro and macro levels, should be encouraged to effectively monitor the social impacts of biofuel development. This is very much needed as the biofuel industry in the East Asian region is poised to grow and more and more people would get involved in it.

5. INTEGRATED ASSESSMENT – ENVIRONMENTAL, ECONOMIC AND SOCIAL INDICATORS

5.1. Introduction

Sustainability is usually considered to entail environmental, economic and social concerns. This has been captured in the working group study by three indicators, one each for the three concerns – lifecycle greenhouse gas (GHG) emissions for environmental, total value added (TVA) for economic, and human development index (HDI) for social concerns. It is recognized that having a single indicator facilitates decision-making as it is relatively straightforward to rank various options when each option has a single "sustainability" value attached to it. However, as the three components of sustainability address very different issues and cannot easily be defined using a common metric, integrating them into a single indicator is not attempted here. Also, combining the three indicators into a single one tacitly assumes interchangeability/tradability among the three issues of sustainability which is inappropriate. However, to aid policy-makers, a visualization technique is presented wherein all three indicators are shown together in a single diagram.

The developed visual presentation scheme will be then applied to the pilot studies conducted as part of this project. ***It must be emphasized at the very outset that various case studies from different sites and conditions should not be compared; this would in fact be not correct. The diagram facilitates only a comparison of that particular project option with the situation if the project was not undertaken (baseline).***

5.2. Normalization of Indicators

For the purpose of neat presentation on a single diagram as well as to avoid the need for presenting multifarious units for the different indicators (sometimes even for the same indicator), a normalization scheme is developed for representing the indicators as dimensionless numbers.

5.2.1. Environmental Indicator

Lifecycle GHG emissions from the projects have been used to represent the environmental aspect of sustainability. The issue of importance is the GHG reductions that can be achieved by the project as compared to the baseline of “no-project”. For example, if biodiesel is produced as an output of the project, then the baseline of comparison could be the petro-diesel which would be replaced. Similarly, for bioethanol, the baseline would be gasoline and so on depending on what is replaced in the “no-project” situation. The lifecycle GHG values (in mass of CO_2 equivalents) for calculating the indicator could either be per volume, mass or energy of fuel produced (and replaced) or per area (or a certain reference area) per annum depending on convenience/data availability.

The Normalized Environmental Indicator (NEnI) can be computed as follows:

$$NEnI = \frac{GHG_{no-project} - GHG_{project}}{GHG_{no-project}}$$

In general, the NEnI would vary between 0 and 1 if some level of GHG reduction is achieved; though in special cases when large credits are obtained from substitution of for example, highly polluting fossil resources, a value larger than 1 is possible. A negative value is also possible if the project results in an increase in GHG emissions; of course this situation is not desirable.

5.2.2. Economic Indicator

TVA due to a project has been selected as the indicator of economic performance. The TVA for different projects are represented in monetary terms, usually based on the local currency. Also, the amount of value added can vary drastically for different projects. For a visually appealing presentation and in line with the logic of presenting a dimensionless value, the cost of the project is chosen as the normalizing reference.

The Normalized Economic Indicator (NEcI) can be computed as follows:

$$NEcI = \frac{TVA_{project}}{Cost\ of\ the\ project}$$

The units of TVA as well as (annualized) cost of the project are represented in monetary values per area (or a certain reference area) per annum. The lowest values of NEcI should be 0. There is, in principle, no upper limit to the value of NEcI; the normalization just serves to non-dimensionalize the TVA and to present it as a factor/multiple of the cost of the project.

5.2.3. Social Indicator

The HDI has been used as the primary indicator to assess social performance of the project. The change in HDI due to the project when compared to the baseline situation represented by the average HDI of the region indicates the effect of the project on the social aspect.

The Normalized Social Indicator (NSoI) can be computed as follows:

$$NSoI = \frac{HDI_{project} - HDI_{no-project}}{HDI_{no-project}}$$

Usually, the NSoI will vary between 0 and 1; 0 if there is no change in HDI due to the project and 1 if the HDI reaches the theoretical maximum value of 1. In cases, where the HDI after the project implementation is lower than the average HDI of the area, then a negative value could be obtained for NSoI. This is, of course, not a desirable situation.

5.2.4. Integrated Presentation of Sustainability Indicators

The three normalized indicators representing environmental, economic and social issues can be presented in a triangular radar diagram format as follows:

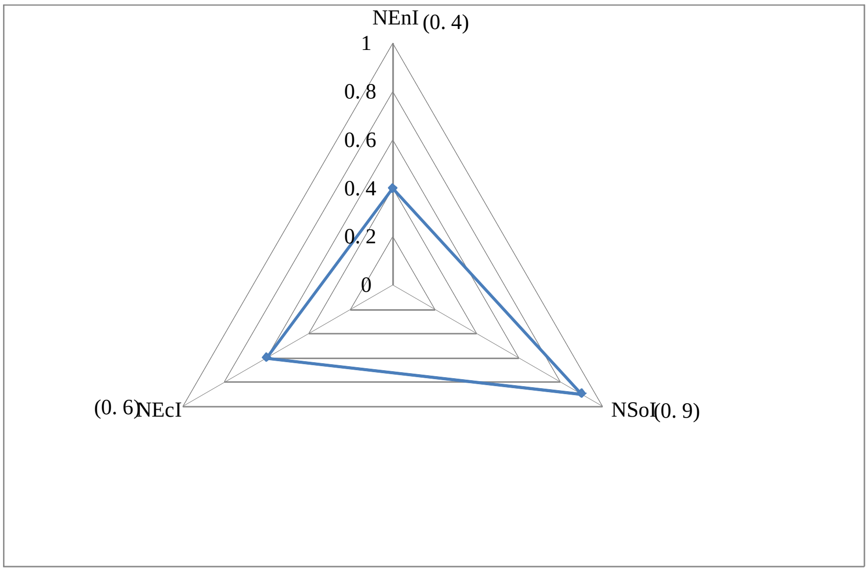

Figure 5-1 Presentation of integrated results for a hypothetical example (NEnI = 0.4, NEcI = 0.6, NSoI = 0.9)

The figure indicates at a glance that the project (hypothetical) results in GHG reduction of 40%, the TVA is 60% of the cost of the project as compared to the baseline case of “no-project”, and that an HDI increase of 90% of the maximum possible increase. More than one alternative potential projects in the same area may also be compared using this configuration using this quick visual representation technique. However, this would require *ex ante* calculation of the indicators.

6. CONCLUSION AND RECOMMENDATIONS

The Project on ‘Sustainable Biomass Utilisation Vision in East Asia’ (Sagisaka., 2008) entered its third phase in March 2010 and, over a very brief period of six months, four pilot studies were implemented in India, Indonesia, Philippines and Thailand. The main objective of these studies was to test the WG methodology on sustainability assessment, covering environmental, economic and social indicators, through its application on select project sites. Since each project site was evaluated for all three aspects of the sustainability, it was possible to obtain values of three sets of indicators.

6.1. Practicality of the Sustainable Assessment Methodology

The four pilot studies provided a range of scenarios with respect to the use of biomass for bioenergy generation. Some of the similarities among the pilot studies are as follows.

- The emphasis of the respective country governments to utilise biomass for production of renewable energy, which may reduce their expenditure on fossil fuel imports.
- Most of the participating companies/ groups are comparatively recent entrants into the biofuel business and are not operating at a maximum design capacity.
- The value chain covered feedstock (biomass) production, its conversion to biofuel and use of final products.

However, there were some distinct differences among the pilot studies such as:

- Sources of biomass feedstock (Jatropha, cassava, coconut and sugarcane)
- Stage of development of the feedstock (Jatropha and other tree oils are still under development as against the established planting of cassava, coconut and sugarcane)
- Size of enterprises involved in the production and use of the bioenergy resources (small holders to large companies)

- The stimulus to go into biomass energy generation and utilisation (energy self-sufficiency at the local level as against business expansion for the biofuel market)

In spite of the differences, the same set of questionnaire was used for all four pilot studies and for every stakeholder in the value chain so that the output of the pilot studies could be used to gauge the applicability of the assessment methodology from small to large projects.

As highlighted in all four reports, data collection to calculate the environmental, economic and social indicators represented by major indices, TVA, GHG savings and HDI change, respectively, was a major challenge. The raw data required to give a value to any one of the indices could be as voluminous as shown in Table 6-1. For all the studies, more than hundred sets of data were obtained through interviews, calculations based on primary data collected, and secondary data from elsewhere. The intensity of data collection and calculation was conspicuous for all the pilot studies.

The indices used to represent the three sustainable indicators of economics; environment and social were based on the guidelines developed by the WG experts. Appropriate strategies, such as well-structured training programmes, etc., are required to disseminate these guidelines in East Asia to ensure their acceptance.

Table 6-1 Summary of raw data required for calculating the values of sustainable assessment indicators of biomass energy

Indicator	Index	Data Required
Economic	Net Profit	Production costs, Yield output, Market Price of output
	Employment	Jobs created per ha up to tonne of biofuel
	Tax Revenues	Tax collected
	Foreign Exchange	Foreign exchange earnings from exports or foreign exchange savings from imports of per unit of fossil fuel
	Total Value Added to the Economy	Net profit + tax revenue + wages and salaries paid + net forex earnings
Environment	Life Cycle GHG Emissions and GHG savings	Cradle to grave inventory of input of diesel, electricity and fertilisers, and chemicals; and output of biofuel versus fossil fuel, and computing savings from zero to 100% blends
Social	Change in HDI between national and project site	Life expectancy, Adult Literacy, Gross Enrolment Ratio and GDP for the region where the project was carried out
	GDI	Computed as percentage of HDI

From the four pilot studies, the practicality of performing the sustainability assessment can be summarised as:

- Although a time consuming and human resource intensive exercise, the necessary data sets required to calculate the assessment indicators would include primary data from field surveys and secondary data from literature.
- The same questionnaire was adapted and used for all stakeholders in the value chain. Whilst each project team did some modification, the key elements and format were similar for all four pilot studies. The questionnaires that were developed by the WG Team are suitable for collecting primary and secondary data for calculating the indicators.
- The experience from the pilot studies has shown that substantial amount of qualitative information were obtained in the course of collecting primary data through interviews and site visits. This information assisted greatly in developing recommendations for enhancing the sustainability of the biomass energy projects.
- Due to the qualitative information that can be obtained through the questionnaire, personnel who will collect the primary data need to be trained on

the three aspects of sustainability and also have good understanding of biomass energy in order to maximise benefits from data collection exercise.

6.2. Scope and Limitations of the Sustainability Assessment Methodology

Table 6-2 summarises the output from each project and shows the wealth of information that can be obtained when the project is carried out with a holistic approach covering all three indicators of sustainability. Although it is possible in some part of Table 6-2 to make a comparison among studies, in terms of absolute values between different biomass feedstock and different locations (reading across Table 6-2), such a comparison was not done in this report in view of site and context specificity which are significant contributors to the results generated for some indicators. The results of the pilot studies have shown that, for a given site and boundary, it is feasible to utilise the methodology as one among other influencing factors, to produce useful quantitative data that can enhance the decision-making process for options such as choice of feedstock or other related biomass energy utilisation activities.

As it is difficult to assign the impacts, created by the biomass energy activities, to each of the sustainability indicators, the WG has proposed the adoption of an integrated dimensionless index. Further, a visual presentation of this index in the form of a radar diagram is developed. This would allow readers to see the connectivity or linkage among various indices and make decisions that are actually based on the output of the assessment methodology. Changes within the radar diagram due to changes in any one or all of the indices that, in turn, are related to changes within a biomass energy project, programme or activity can be tracked more easily.

The four pilot studies were conducted with the primary purpose of testing out the methodology and were implemented without any policy or decision-making objective in mind. The studies have shown the necessity of establishing clear goals and scope that will provide guidance on how results of the study will be interpreted and used. Some of the these goals could be comparison of options related to types of biomass materials; utilisation of biomass resources; identification of areas for improvement; and/ or establish rate of success of biomass energy programmes that were introduced with some other aspects of sustainability such as national energy security, rural employment generation, etc.

The output from all four pilot studies represented results of existing practices. In this respect, the usefulness of the indicators would be identification of the 'way forward' based on scenarios that can be created by changing some aspects or parameters within the related formulae. A good example is the various options for using the biogas from the wastewater treatment plant of the bioethanol factory that use cassava as the feedstock in Lampung, Indonesia. With such changes, the environmental and economic impacts could be clearly compared for the various options.

Due to limitation of time, the assessment methodology could not be applied to assist in choice of feedstock, technologies and land use changes of projects or activities. The methodology for pre-existing projects remains the same but the mode of data collection for the questionnaire will be different. Among the suggested modes of data collection include obtaining data from existing similar projects at other locations and adapting or regionalising them to best-fit the local condition or site of study. Users of the methodology need to describe clearly the assumptions (similarities and differences) and limitations when using data that is collected from another site.

The pilot studies were carried out at specific sites, representing events and characteristics at the micro-level. The same mode of implementation when carried out at macro level, such as provincial (state), national or regional level, is feasible using the same methodologies for each of the indicators but will require pooling data that are more representative such as data from various associations (farmers, manufacturers, traders, etc.).

From the reports of the pilot studies, it is also evident that in addition to the empirical values of the indicators, extensive and elaborate information on qualitative aspects was available that could be used to interpret the results. Hence, qualitative descriptions may have to be included as part of the output of the assessment methodology. To ensure a thorough comparison of the output from the studies, the topics to be covered and format of presentation of the qualitative information should be established.

In addition to an established format of presenting the qualitative section, Table 6.2 also highlights the need to include a summary presentation within the report format to enable readers, in particular, policy makers and those who do not wish to get into the details of calculations to grasp the implications of the values attached to each of the indicators.

In summary, the sustainability assessment methodology produced tangible and measurable indices that could be linked to environmental, economic and social impacts as:

- Green House Gas Savings (by replacing fossil fuel with biofuels)
- Total Net Profit and Total Value Added
- Change in Human Development Index

It must be reiterated that the output of the pilot studies i.e. the values established for each of the indicators should not be interpreted beyond their purpose of testing the methodologies. There were no specific measurable goals for the pilot studies to address.

6.3. The Way Forward – Enhancing Use and Output of the Sustainability Assessment Methodology

The pilot studies have identified areas some of which could be taken up for inclusion in the 'Guidelines to Assess Sustainability of Biomass Utilisation in East Asia' (ERIA, 2009), specifically the each methodology that has been developed to address the three aspects of sustainability. The indicators identified gave satisfactory results but some fine-tuning of them is required as has been elaborated in the individual chapters. It is suggested that additional preliminaries, preparation, format of presentation, reporting and interpretation of results should be considered by any individual or group prior to embarking on a study using the methodologies.

6.3.1. Clarity of Goals and Scope of Study

For application of the assessment methodology in any study, it is necessary to state clear goals and scope, expected output or inferences, etc., *a priori*. Some of the examples of such goals could be - comparison of options of different choices of biomass resources, different utilisations of the biomass resources, establish continuity of biomass energy programmes that are already ongoing, identify areas for improving sustainable utilisation of existing biomass energy initiatives, etc.

6.3.2. Units and Measurements

It is advisable to use common units of measurements in all studies, e.g. USD/ha/yr; USD/yr (as national savings); GHG savings as kg-CO_2eq/ha/yr or in %; GHG footprint of the biomass energy in kg-CO_2eq/MJ.

Although normalisation of indicators will remove the multifarious units, absolute values are equally important for benchmarking or quantitative comparisons. Common unit for monetary value e.g. USD should also be considered if regional application of the methodology is conducted.

6.3.3. Establish Data Collection Procedures

Having established clear goals for the study, the data collection procedure should, among others, address the representativeness of the data that will be collected by establishing temporal (time) and spatial coverage e.g., how many years of data are needed to calculate change in HDI, GHG savings or net profit since yields, price of commodities, GDP, etc., which may vary on annual basis as well as across countries.

There is a need to provide limits or boundaries of extrapolation of data from micro to macro level for each indicator. When data are being collected for the purpose of simulation at another site, it is also important to define degree of adoption, adaptation and modification to enable those who are doing the actual ground work to garner the necessary information. The data collection procedure should also establish the units and measurements that will eventually be required for calculation of the indices, especially secondary data that can be available in units of measurement that require complex conversion steps to reach the desired unit. References for sources of secondary information or data should be reported in a format that will enable easy traceability, particularly those references/studies that will be used as the basis for decision-making.

6.3.4. Reporting Format

The Guidelines developed under the ERIA Project for Sustainability Assessment of Biomass Utilisation do not provide a standard format for reporting the output of a study carried out using the methodologies. The advantage of this approach is that it provides flexibility to users of the Guidelines to tailor their report according to the local requirements of the study.

A comprehensive report should include a summary table for reporting the indicators together with background information, assumptions and limits in absolute values; the radar diagrams after working out the normalisation indices; recommendations based on calculated results or qualitative information decoded during data collection at ground.

6.3.5. Adoption of International Standards

When conducting studies where the methodologies are already available as international standards, namely, ISO standards, the procedures should closely follow to produce results that are more easily interpreted or where needed, comparisons between the available options e.g. ISO standards for lifecycle assessment and carbon footprint.

6.4. Overall Findings of the Sustainable Assessment Methodology

Highlights of the results and salient features of the pilot studies are summarised as follows.

- Indicators like GHG savings; total net profit (TNP) and total value added (TVA); and improvement in human development index (HDI) are suitable for assessing the environmental, economic and social sustainability, respectively, of biomass energy utilisation.
- Environment indicator chosen for this phase of the project covers only GHG savings which is very relevant to current concerns on biofuels. Evaluation of GHG for global warming using LCA is appropriate but other emissions and impacts can also be considered. Other than global warming, impact categories such as land use change, acid rain, eutrophication, ecotoxicity, human toxicity

and resource depletion affect the locality where the emissions or depletion occur. Hence, ranking these impact categories according to local needs as a full LCA study up to the life cycle impact assessment stage may be appropriate, although collecting the information and data will be an uphill task for the developing countries.

- Economic indicators, namely, TNP, TVA and Forex savings, are internationally accepted. It should be emphasized that there should be a business component throughout the value chain and net profit is positive.
- Social indicators such as literacy rate, education enrolment, life expectancy, gender empowerment, etc., are relevant to the state of development of East Asian countries. Although HDI is widely applied to evaluate social impact at state, regional or national level, there is a need to develop an index or some indices that can better represent social impact at the community level. Some of the social indicators, that are reported in the Social Life Cycle Assessment, such as child labour, minimum wage rates, forced hours, labour unions, etc., are excellent for developed countries but would not be applicable to developing economies that have to grapple with issues of poverty, employment and an expanding population that has to be provided with basic amenities through enhancing rural economy.
- Utilisation of all by-products in the production of biomass energy is very much recommended to increase the sustainability of soil, reduce environmental impact, and optimize social and economic benefits.
- Sustainability can be viewed at different levels using appropriate indicators at community, regional and national levels.
- "Guidelines for Sustainability Assessment of Biomass Utilisation" may be applied to each country in the East Asian region with minor locale-specific modifications. Training is recommended in order to apply the guidelines in East Asian countries properly.
- Dissemination of Guidelines on Sustainable Biomass Utilisation and experiences of the pilot studies may be helpful to other East Asian Countries

and organizations such as the Global Bioenergy Partnership and the International Organization for Standardization.

- Finally, it must be noted the assessment methodology developed is tailored only for the biomass renewable resource and may not be applicable for comparison with other renewable energy resources such as solar energy, wind energy or wave energy. Although sustainability encompasses the three pillars of environmental, economic and social, the specific indicators and mode of calculations including the boundaries and scope of comparison will differ. Such differences have not been considered by the Working Group whose focus is primarily on looking at options and issues pertaining to biomass utilisation.

Table 6-2 Comparison of project output for the three major indicators for pilot study sites at current status or practice

Indicators	Jatropha/Biodiesel		Cassava/Bioethanol	Coconut/Biodiesel	Sugarcane/Bioethanol
	India	Indonesia	Indonesia	Philippines	Thailand
Environment					
• Life Cycle GHG Emissions	1668 t-CO_2eq/yr	12.59 kg-CO_2eq/GJ	14.05 kg-CO_2eq /GJ	1,267 kg-CO_2eq/ha/yr	124 kg-CO_2eq/t cane
• Life Cycle GHG savings	2,771,681 t-CO2eq/yr		70.75 kg-CO_2eq/GJ	2,824 kg-CO_2eq/ha/yr	41,955 t-CO_2eq /yr
Economic					
• Total Value Added (final product)	11,161,637USD/yr			1,325 USD/ha/yr	3,861 USD/ha/yr
• Total Net Profit (final products)	5,987,467 USD/yr	157 USD/ha/yr	956 USD/ha/yr	845 USD/ha/yr	14,281 USD/ha/yr
• Total Net Profit (feedstock)		- 175 USD/ha/yr	610 USD/ha/yr	693 USD/ha/yr	4,163 USD/ha/yr
• Wage (Revenue)	0.057 USD/unit	85 USD/ha/yr	1285 USD/ha/yr	305 USD/ha/yr	1,526 USD/ha/yr
• Forex Savings	9,210,283 USD/yr 1609 USD/ha/yr	-	-	-	545.6 USD/ha/yr
Social					
• HDI of Project Site	0.616	0.541	0.560	0.785	0.765*
• Change in HDI	0.004	<HDI (macro)	<HDI (macro)	0.00393	0.002
• GDI	0.604	0.349	0.541	0.784	-

*Note: * The average of plantation and biorefinery complex*

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