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Guidelines to Assess Sustainability of Biomass Utilisation in East Asia

Edited by

Masayuki Sagisaka

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Working Group Leader

SAGISAKA Masayuki：Dr. Eng., Deputy Director, Research Institute of Science for Safety & Sustainability, National Institute of Advanced Industrial Science & Technology (AIST), Japan

Working Group Members: (in alphabetical order)

CHEN Sau Soon：PhD, Senior General Manager, Environment & Bioprocess Technology Centre, SIRIM, Malaysia

Jessie C. ELAURIA：PhD, Professor, Institute of Agricultural Engineering, College of Engineering and Agro-industrial Technology, University of the Philippines Los Banos College, The Philippines

Shabbir H. GHEEWALA：Dr. Eng., Associate Professor, The Joint Graduate School of Energy and Environment (JGSEE), King Mongkut's University of Technology Thonburi, Thailand

Udin HASANUDIN：Dr. Eng., Head, Department of Agroindustrial Technology, University of Lampung, Indonesia

KHOO Hsien Hui：PhD, Research Fellow, Institute of Chemical & Engineering Sciences (ICES), Singapore

SADAMICHI Yucho：Dr. Eng., Lecturer, Life Cycle Management Centre, Chiang Mai University, Thailand

Vinod K. SHARMA：PhD, Professor, Indira Gandhi Institute of Development Research (IGIDR), India

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1. INTRODUCTION

1.1 Background

A Working Group (WG) of experts and researchers, supported by ERIA since 2007, is engaged in research and discussions on "Sustainable Biomass Utilisation Vision in East Asia." The WG produced a report [1], which listed seven major policy recommendations for sustainability of bioenergy in the East Asian region.

Based on these policy recommendations and the background studies conducted by the WG, "Asia Biomass Energy Principles" were framed and reported to the East Asian Summit of Energy Ministers and endorsed by the Ministers in August 2008. The Ministers requested ERIA to develop a methodology for assessing the environmental, economic and social sustainability in production and utilisation of biomass taking into account specific regional circumstances at the meeting. In response to this, the WG initiated investigations for developing "Guidelines to Sustainability Assessment of Biomass Utilisation in East Asia."

1.2 Discussion

Sustainable development is of utmost importance and a serious concern world over. Any development activity that is not appropriately implemented and managed could lead to environmental disaster. There is a possibility of negative environmental impacts of using biomass as feedstock for production of biofuels. And therefore, policy makers should think about the sustainability of biomass projects prior to framing the relevant policies. The assessment methodology for the sustainability is a key decision-support tool. The WG adopted the definition of "sustainable development" from "Our Common Future" of the UN World Commission on Environment and

[1] "Sustainable Biomass Utilisation Vision in East Asia"; ERIA Working Group, ERIA Research Project 2007 No.6-3, pp1-148, 2007

Development (WCED) report published in 1987, which defines the sustainable development as the "development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

The triple bottom line approach, focusing on "People, Planet, Profit," is based upon economic, environmental and social criteria. To ascertain the sustainability of bioenergy development, these aspects are necessary and must be considered to overcome or at least minimise the problems that may occur with the expansion of biomass energy utilisation. In view of the above, the WG, continued research and discussions in 2008. Based upon this research and the previous year's achievements WG produced this report titled as "Guidelines to Assess Sustainability of Biomass Utilisation in East Asian Countries".

1.3 Biomass in East Asian Countries in 2008

Some of the major policy interventions on biomass utilisation, as adopted by selected countries in the East Asian region in 2008, are as follows.

(India)

The Union Cabinet approved the National Policy on Biofuel prepared by the Ministry of New and Renewable Energy in September, 2008. Salient features of the National Biofuel Policy are as follows:

- An indicative target of 20% by 2017 for the blending of biofuels, i.e. bioethanol and bio-diesel, has been proposed.
- Bio-diesel production will be taken up from non-edible oil seeds in waste / degraded / marginal lands.
- The focus would be on indigenous production of bio-diesel feedstock and import of Free Fatty Acid (FFA) based such as oil, palm etc. would not be permitted.
- Bio-diesel plantations on community / Government / forest waste lands would be encouraged while plantation in fertile irrigated lands would not be encouraged.
- Minimum Support Price (MSP) with the provision of periodic revision for bio-diesel oil

seeds would be announced to provide fair price to the growers. The details about the MSP mechanism, enshrined in the National Biofuel Policy, would be worked out carefully subsequently and considered by the Bio-fuel Steering Committee.

・Minimum Purchase Price (MPP) for the purchase of bio-ethanol by the Oil Marketing Companies (OMCs) would be based on the actual cost of production and import price of bio-ethanol. In case of biodiesel, the MPP should be linked to the prevailing retail diesel price.

・The policy envisages that bio-fuels, namely, biodiesel and bio-ethanol may be brought under the ambit of declared Goods by the Government to ensure unrestricted movement of biofuels within and outside the States.

・It is also stated in the Policy that no taxes and duties should be levied on bio-diesel.

(Indonesia)

Starting January 1st 2009, users and fuel distributors are obligated to use biofuel, with products such as biodiesel, bioethanol, and biokerosene. This mandatory use is stipulated in Minister of Energy and Mineral Resources Decree no 32/2008. "This mandatory use is a way of increasing biofuel usage for the transport, industry, and power sectors". Besides supporting the energy diversification program, this step is also expected to contribute in reducing fuel subsidy costs. The government mandates the use of biodiesel at a minimum of 1% for the transportation sector (both PSO i.e public service obligation and non PSO), while the industrial and commercial sectors are targeted at 2,5% and power plants at 0.25%.

The government has mandated the use of bioethanol at a minimum of 1% for the PSO transportation sector, 5% for the non PSO transportation sector, and another 5% for the industry and commercial sectors. Biofuel as a source of alternative energy is targeted to fulfil 0.25% of the power plant fuel needs, while low and medium rpm operating machines of the industrial and sea transport are targeted at 1% each, starting January 2010.

These numbers are set by the government in order to implement the targeted usage of Biofuel of 5% by 2025. This biofuel will be domestically supplied, and not imported. Main problem on the implementation of biofuels' utilisation is their price. Fossil fuel price in Indonesia have subsidy, and therefore, biofuels are not competitive in the market. Government now has initiated a new regulation system like subsidy system for biodiesel and bioethanol.

Related to biomass waste from agro-industries, this year, Ministry of Environment, Republic of Indonesia, started developing a program "Agro-industry to zero-waste programs". The objectives of this program are to reduce negative impact of agro-industries (such as soil and water pollutions, GHGs emissions, etc.) and increase revenue from the utilisation of biomass waste from agro-industries.

(Japan)

Government of Japan launched "Technology Innovation Plan for Biofuels" in 2008. The final target of the plan is to achieve 50% reduction in the GHG emissions during the lifecycle of biofuels and the target cost is less than 40 Japanese yen per liter of the biofuels. Some R & D projects have been initiated to realise the above plan.

(Malaysia)

The National Biofuel Policy is the main biodiesel policy in Malaysia. It was launched by The Federal Government on 10th August 2005. The policy is primarily aimed at reducing the country's fuel import bill, promoting further the demand for palm oil, which will be the primary commodity for biofuel production (alongside regular diesel), as well as to shore up the price of palm oil especially during periods of low export demand.

The National Biofuel Policy is complemented by Malaysian Biofuel Industry Act 2007 (Act 666) that was enforced this year and will enable the orderly development and regulation of the industry. In addition, the Act also allows the Government to mandate the use of biofuel for any activity in the country. It prescribes the type of biofuel and its percentage by volume to be blended in any fuel. The Act also deals with the provisions relating to revocation or suspension of biofuel plant license, It empowers the licensing authority to revoke or suspend any license if the licensee has ceased to carry on or operate any biofuel activity for which the license is issued

In October 2008, Malaysia implemented the mandate of a 5% palm methyl ester blend with fossil diesel (B5), gradually starting with its use in government vehicles in 2009 and extending it to the industrial and transportation sectors in 2010. The use of the B5 blend in the country would consume 500,000 tonnes of palm oil.

(The Philippines)

In the Philippines, the overall vision of the government on biofuels' use includes the reduced dependence on imported energy and broader resource base with an indigenous, inexhaustible and environmentally desirable options such as the use of renewable energy (RE) including biomass energy. Biomass will be used in "Support of Alternative Transport Fuels Program" of the government.

For the next decade, the country through the Department of Energy (DOE) is set to pursue an aggressive RE program and includes under its goals the following: increase renewable energy-based capacity by 100% in 10 years, use of 5% CME blend with diesel fuel for vehicles in 2010, and 10% ethanol blend with gasoline fuel for vehicles by 2007 to reach 25% in 2010. It also includes the installation of 130 to 250 MW capacity of biomass, solar and ocean energies. To support its objectives, the government passed two bills into laws, namely, RA 9367 or the Biofuels Law that mandates the use of biodiesel and bioethanol nationwide and RA 9513 or the Renewable Energy Act.

(Thailand)

The target proposed by the Ministry of Energy is "Increasing the proportion of using alternative energy to 20 percent of the national final energy consumption by 2022". The objectives are to reduce oil imports, enhance energy security, environmental benefits and energy efficiency.

The plan will be implemented in three phases, i.e.

Short Term (2008-2011): Focusing on promoting the proven alternative energy technologies with high potential sources such as: biofuels, heat and power generation from biomass and biogas. The financial support measures will be fully implemented.

Medium Term (2012-2016): Promoting the alternative energy technology industry and supporting the development on new prototype of alternative energy technology for a higher cost-effectiveness. This includes promoting new technologies for biofuel production.

Long Term (2017-2022): Promoting new technologies of alternative energy which are cost-effective. Supporting Thailand to become the hub of biofuel export and exporting the alternative energy technology in the ASEAN region

Table 1-1: Alternative Energy Target of Thailand

Alternative Energy Target of 20.4% in 2022 (data only for biomass)					
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

1.4 Worldwide Discussion on Sustainable Bioenergy

The EU adopted the "Directive on Renewable Energy" to set standards for biofuel with regard to reduction of greenhouse gas emissions and environmental impacts in December 2008. GBEP (Global Bioenergy Partnership), which was established by the G8 Summit, is developing international sustainability standards for biofuels. ISO (International Standardisation Organisation) is going to start discussion on standard of “Sustainability Criteria for Biofuels”. Some other organisations are also discussing this issue worldwide and details of this are given in Chapter 2.

These discussions and developing criteria must be quite meaningful but the opportunity to participate in such discussions should be given to all stakeholders. Since the East Asian region has a large potential for production and consumption of biomass resources, the concerns of the region should be part of the above discussions. Also, such concerns should be backed by scientific considerations and local experiences as well as state of development. The discussion within the WG of the ERIA and this report are expected to contribute towards the scientific base and the concerns on bioenergy that may emerge from the region.

2. GLOBAL DISCUSSIONS ON SUSTAINABILITY OF BIOMASS DERIVED FUEL

2.1 Introduction

Global energy demand is propelled by two main sectors namely electricity generation and transportation. Net electricity generation has been forecasted to increase from 18 trillion kWh in 2006 to 31.8 tillion kWh by 2030[2]. Transportation sector is projected to consume 127.7 quadrillion Btu of energy by 2030, an increase of about 39% from 2006[2]. At the same time, projection of increase in world energy-related CO_2 emissions will accelerate from 29 billion metric ton in 2006 to 40.4 billion metric ton in 2030[2].

It is against these two scenarios of escalating energy demand and global warming that energy security and greenhouse gas (GHG) reduction have become global concerns and the global approach seems to be targeted at renewable energy (RE). For example, policy targets for renewable energy exist in at least 66 countries worldwide[3] among the more challenging ones is the EU-wide target of 20% RE target in the final energy demand, and 10% biofuel target in the transport energy demand by 2020. Aside from the target-setting policies, there are other forms of RE promotion policies broadly categorised[3] under:

- Feed-in tariff
- Renewable portfolio standard
- Capital subsidies, grants or rebates
- Investment or other tax credits
- Sales tax, energy tax, excise tax, or VAT reduction
- Tradable renewable energy certificates

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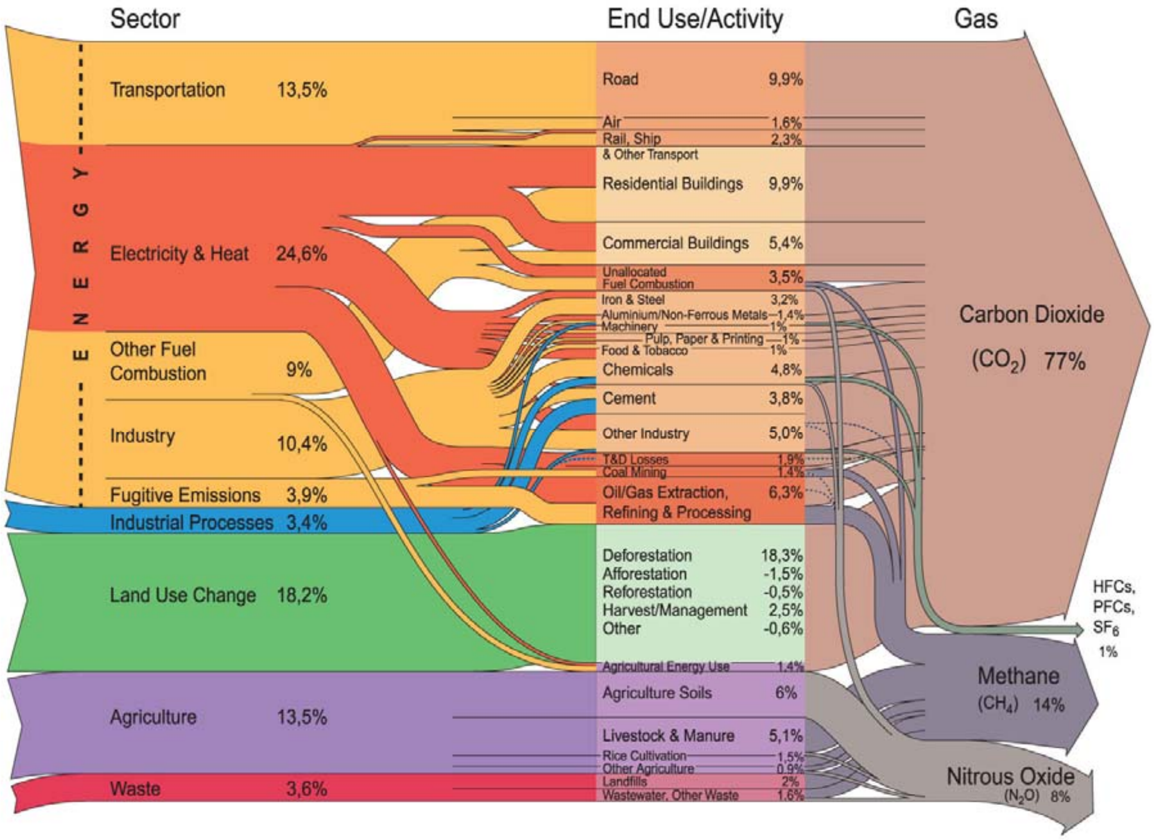
2 Energy Information Administration, International Energy Outlook 2009, http://www.eia.doe.gov/oiaf/ieo/index.html.

3 REN21.2008 “Renewables 2007 Global Status Report” (Paris:REN21 Secretariat and Washington, DC:Worldwatch Institute)

- Energy production payments or tax credits
- Net metering
- Public investment, loans or financing
- Public competitive bidding

In terms of the two major energy-consumption sectors i.e. power generation and transport, bioenergy or biofuel has made greater in-roads into the transport sector evident by the biofuel policies with mandates for blending biofuels ranging from E1 (1% blend) to E25 (25% blend) for bioethanol and B1 to B20 for biodiesel with target time frames of up to 2015.

While policies to support growth of the biofuel industry is on the rise especially among the developing countries that have seen RE as a potential fast-growing economic sector. There is also an increasing awareness that the 'carbon neutral' perspective of biofuel at the point of combustion may be negated by emissions from the production process, especially when viewed from a life cycle perspective beginning with the biomass feedstock material and land-use change. Figure 1 shows that transportation and electricity (& heat) sectors account for about 40% of the world GHG emission. The prospect of capping or reducing GHG emission through RE to fulfil obligations of Annex I countries under Kyoto Protocol is also one of the drivers for the RE growth.



[4]Figure 2-1: World greenhouse gas emission by sector, power and transportation sectors account for ~40% of the world GHG emission.

Central to the discussion of environmental sustainability versus energy security or the carbon and energy balance is the rising concern that the reduction in the life cycle GHG emission of bioenergy may not be significant enough to warrant the investment, exemptions and subsidies that have propelled the growth of the RE sector, including the biofuel industry.

As natural disasters attributed to global warming and climate change become more evident, the pressure to reduce GHG emissions has transcended from policy makers to society at large, especially in the developed countries where awareness of these phenomenon are higher. This has given rise to strategies such as developing carbon footprint or ecolabelling of products that will enable purchasers to exercise

[4] Source: UNEP G.R.I.D Arendal, http://maps.grida.no.go.graphic/world-greenhouse-gas-emissions-by-sector

their purchasing power for goods that emit less GHG or has less environmental impact.

However quantification of GHG emissions to provide the size of the carbon footprint or other forms of environmental impacts is not standardized among the various labelling schemes, guidelines or regulations. At the same time, there are a number of initiatives undertaken by various international and regional organisations to develop standards, guidelines and directives on the quantification and communication of GHG emissions data. Among them are:

- ISO 14064-1:2006 - Greenhouse gases- Part 1: Specification with guidance at the organisation level for quantification and reporting of greenhouse gas emissions and removals (Organisation level)
- ISO 14064-2:2006 Greenhouse gases – Part 2: Specification with guidance at the project level for quantification, monitoring and reporting of greenhouse gas emission reductions or removal enhancements (Project level)
- ISO 14064-3:2006 Greenhouse gases – Part 3: Specification with guidance for the validation and verification of greenhouse gas assertions (reviewer in LCA)
- ISO 14067-1 (New Project Approved) Carbon footprint of products – Part 1:Quantification
- ISO 14067-2 (New Project Approved) Carbon footprint of products – Part 2: Communication
- PAS 2050:2008 Specification for the assessment of the life cycle greenhouse gas emissions of goods and services
- Global Bioenergy Partnership (GBEP) Framework for GHG Measurement
- Proposed Directive of the European Parliament and of the Council on the Promotion of the Use of Energy from Renewable Sources
- ISO New Work Item Proposal (NWIP) for Sustainability Criteria for Biofuel
- Roundtable on Sustainable Palm Oil (RSPO) and Roundtable on Sustainable Biofuels (RSB)

The coverage of these initiatives are listed in Table 2-1.

Table 2-1: Summary of Documents Related to GHG Estimation, Measurement and Reporting

No.	Name of Document	Publisher	Coverage
1.	ISO 14064-1:2006	ISO	Quantification of GHG at organisation level
2.	ISO 14064-2:2006	ISO	Quantification of GHG at project level Considers sinks and reservoirs
3.	ISO 14064-3:2006	ISO	Verification of GHG measurement
4.	ISO 14067-1 ISO 14067-2 (New Projects)	ISO	Quantification of carbon footprint of products based on life cycle and communicating them
5.	Sustainability Criteria for Biofuel	ISO	Expected to cover economic, social and environmental criteria including GHG emission.
6.	PAS 2050:2008	BSI, Carbon Trust, Defra	Based on LCA, covering every stage including landuse change, default values given Allows for offsets New term on biogenic carbon and its inclusion in the GHG estimation
7.	Global Bioenergy Partnership	FAO, United Nation (as Secretariat)	Exclusively on transport fuels and the biomass used in the production
8.	UK RTFO Carbon and Sustainability Reporting within the Renewable Transport Fuel Obligation	UK Department of Transport	Provides default values and fuel chains for carbon reporting on batch production basis of biofuels used for transportation.

9.	Directive for Promotion of the Use of Energy from Renewable Sources	European Commission	Applies to all applications and forms of biofuel, provides comprehensive formulae, default values and cut-off criteria. Does not consider capture of CO_2 in the cultivation of raw materials.
10.	Round Table for Sustainable Palm Oil (RSPO) Roundtable on Sustainable Biofuels (RSB)	International NGO Higher Research Institution	RSPO is an established third party certification system for sustainable palm oil that includes GHG estimation/quantification. RSB is also based on principles that can be verified and reported. The group has initiated discussions to develop indicators for certification related to the GHG criteria.

2.2 Salient features of guidelines and directives

The ten listed documents are among the most commonly referred guidance document for quantification and communication of GHG. While some are fully established documents, some have yet to commence work although their objectives, scope and justifications have been announced. Among the established, 'yet-to-be-finalised' and 'yet-to-commence documents, it was noted there exist commonalities and differences:

(a) Common Items

- All aimed at providing quantification methodology for GHG profile of product system/ organisation/ project
- Specify reporting format for communication
- Considers life cycle perspective and product system coverage in the case of products (biofuel)

(b) Differences

- Coverage of GHGs numbering 3 (CO_2, CH_4, N_2O) to 6 (+ HFCs, PFCs, SF_6)
- Stages of the life cycle e.g. cradle to grave or cradle to gate (plantation to wheel, plantation to mill)
- Differences in default values (although IPCC values are mentioned in some documents) and conversion factors
- Differences in handling of offsets, carbon payback period, carbon sequestration
- Differences in handling of co-products, including parameters used to prorata the emissions such as by mass, energy or economic value
- Reporting of final data e.g actual GHG value, GHG emission savings, carbon credits

The list of differences is based on the information available in the public domain for each of the document. The different approach will be a burden to the biofuel industry when required to show compliance to reporting the GHG profile according to the specification adopted by a country. Hence the ERIA joint research project is timely in providing a platform among member countries of East Asia to investigate and recommend the appropriate assessment methodology for the sustainability of the bioenergy industry in the region.

3. SUSTAINABILITY ASSESSMENT METHODOLOGY

3.1 ENVIRONMENTAL IMPACT - Life Cycle Approach to Develop Greenhouse Gas Inventory -

3.1.1 Introduction

Life Cycle Assessment (LCA) is increasingly being promoted as a technique for analysing and assessing the environmental performance of a product system and is suited for environmental management and long-term sustainability development. Although LCA can be used to quantitatively assess the extent of impact of a product system toward environmental issues of concern such as acidification, eutrophication, photooxidation, toxicity and biodiversity loss, these impact categories are currently not in the limelight as compared to climate change, a phenomenon that is associated with the increasing frequency of extreme weather conditions and disasters. Effects of climate change have been attributed directly to the increased atmospheric concentration of GHG released by anthropogenic activities.

One of the widely accepted climate change mitigation approach is the propagation of renewable energy for GHG avoidance, and concurrently address the issue of energy security. Biomass that is converted to bioenergy is a source of renewable energy. Hence, the impact of using bioenergy in the transport and power generation sectors will be significant provided the life cycle release is reduced compared to fossil fuel. The cradle to grave life cycle of a type of bioenergy, used for transportation or power generation is shown in Figure 3-1-1.

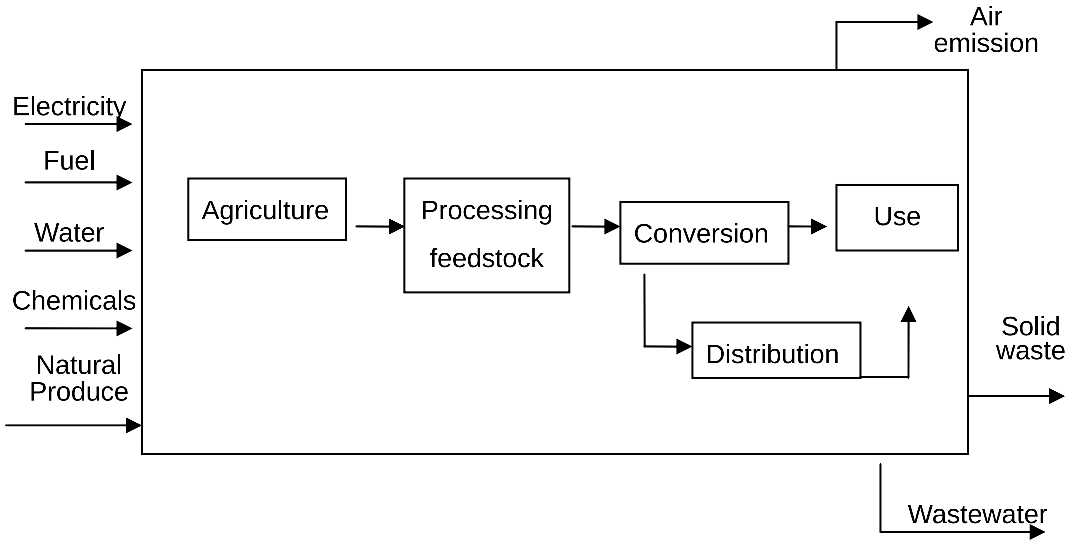


Figure 3-1-1: System boundary for the cradle to grave life cycle inventory of bioenergy

Based on the two main ISO standards on LCA, ISO 14040 and ISO 14044[5], conducting a LCA study consists of four phases. However, in estimating GHG emission specific for biomass energy, only the procedures associated with life cycle inventory (LCI) analysis involving compilation and quantification of inputs and outputs for a given biomass energy throughout its life cycle will be carried out.

The LCI for bioenergy should cover CO_2 and non-CO_2 greenhouse namely CH_4 and N_2O that are released directly or indirectly from agricultural activities. The GHG inventory will be reported as CO_{2equi} and the summation of contribution from non-CO_2 gases will be based on the Global Warming Potential (GWP) for a 100-year time horizon of CH_4 and N_2O at 25 and 298 times, respectively.

3.1.2 Conducting an LCI Analysis of Bioenergy

The life cycle stages of a bioenergy are comprised of the following:

- Agriculture

[5] ISO 14040 Environmental management – Life cycle assessment – Principles and framework
ISO 14044 Environmental management – Life cycle assessment – Requirements and guidelines

- Feedstock processing
- Conversion
- Distribution
- Use

Of the five stages, the cultivation of feedstock materials, summed under agriculture has in most cases contributed to highest emission of GHG. It is in fact highlighted as the stage that requires the most intervention from policy makers. At the same time, it is also the most complex stage where input and output data are not easily measured, and are subjected to estimates and modelling. Hence, the agriculture stage will also be discussed in greater details as compared to the other stages.

(i) Agriculture Stage

The agriculture activities and practices that are contributors to the GHG inventory of bioenergy feedstock materials are:

- Land-use change
- Land fertilisation especially synthetic fertilisers
- Emission from residue degradation in the field
- Emission from soil

There are minimal measured data of the GHG contributions of each of these stages. Most of the studies use equations and default values proposed by the International Panel on Climate Change (IIPCC)[6]. The GHG emissions are primarily related to human activities which:

- Change the way land is used or
- Affect the amount of biomass in existing biomass stocks

(a) Land-Use and Land-Use Change (LULUC)[7]

[6] [Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual]

[7] Intergovernmental Panel on Climate Change: Good Practice Guidance for Land Use, Land-Use Change and Forestry, IPCC National Greenhouse Gas Inventories Programme

There are six Land-Use Categories listed under IPCC: forest land, cropland, grassland, wetlands, settlement and other lands.

Land use change refers to the conversion of one type of land (e.g. forestland) to another (cropland) and leads to changes in carbon in the biomass pools. Table 3-1-1 is a summarised version of the definitions of carbon pools in the terrestrial system according to IPCC, but which can be modified to reflect local conditions.

Table 3-1-1: Brief definition for terrestrial pools based on IPCC guidelines

Pool		Description*
Living biomass	Above-ground biomass	All living biomass (expressed in tonnes dry weight) above the soil including stem, stump, branches, park, seeds and foliage.
	Below-ground biomass	All living biomass of live roots except fine roots <2mm diameter.
Dead organic matter	Dead wood	Includes all non-living woody biomass not contained in the litter and includes wood lying on the surface, dead roots, and stumps ≥10 cm in diameter.
	Litter	Includes all non-living biomass with a diameter < 10cm (e.g.), lying dead, in various states of decomposition above the mineral or organic soil. This includes the litter, fumic, and humic layers.
Soils	Soil organic matter	Includes organic carbon in mineral and organic soils (including peat) to a specified depth chosen by the country and applied consistently through the time series.

To estimate the changes in GHG emission related to a specific land-use change, three sets of information are critical:

- The carbon stock of the original and changed land-use
- The information on land area affected by the land-use change
- The time frame in which the new land-use change will remain status quo until the next change

The first order approach recommended by IPCC to estimate the GHG emission from land-use change is based on the simple assumptions of:

- the change in carbon stock related to land-use change
- biological responses of vegetation and soils following the land-use change

The input data required to establish the GHG inventory for land-use change will be extracted primarily from the IPCC manual. Of the six categories of land identified under IPCC, land that supplies biomass feedstock materials for use or conversion to bioenery can be referred to as 'cropland'. Within the remainder five categories, it is logical to assume the land-use change will take the form of:

- forest land to cropland
- grassland to cropland
- cropland of one type of crop to cropland of another type of crop
- wetland to cropland
- cropland remaining cropland

Working on the assumption that change in carbon stock is assumed equivalent to carbon loss in the form of GHG emission during land-use change, the following equations can be used to estimate the loss:

$$L_{conversion} = C_{After} - C_{Before} \qquad \text{(Equation 1)}[8]$$

$L_{Conversion}$ = carbon stock change per area for that type of conversion when land is converted, tonnes ha^{-1}

C_{After} = carbon stocks in biomass immediately after conversion, ton C ha^{-1} (cropland)

C_{Before} = carbon stocks in biomass immediately before conversion, ton C ha^{-1} (forest land, grassland, wetland, from one type to another type of cropland)

(b) Land preparation and fertilisation

The two main forms of GHG related to agriculture soil management are nitrous oxide (N_2O) and CO_2. N_2O from managed soils of croplands for biomass feedstock materials are released from anthropogenic N inputs or N mineralisation through two

[8] Equation 3.3.8, IPCC Good Practice Guidance for LULUCF, IPCC, 2003

primary pathways[9]:

- o direct emissions from the soil through the natural process of nitrification and denitrification of available N in the soil;
- o indirect emissions through the same natural process as above on NH_4^+ and NO_3^- that have deposited in the soil through two routes involving volatilisation, and leaching and runoff.

Figure 3-1-2 summarises some of the default emission factors obtained from 2006 IPCC Guidelines to estimate direct and indirect emissions of N_2O with respect to N inputs.

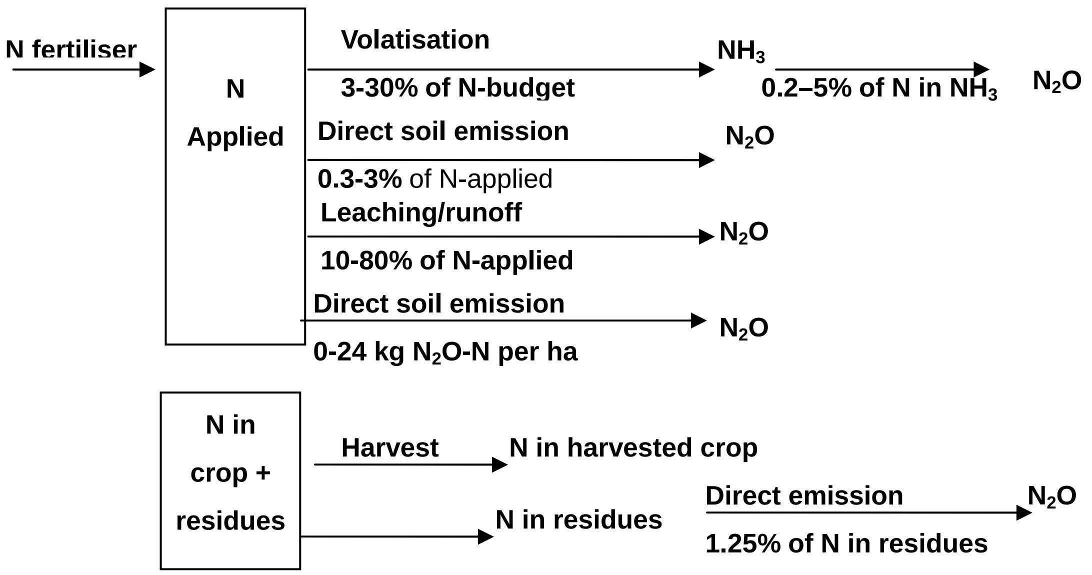


Figure 3-1-2: IPCC method for estimation of N_2O emission based on range of conversion values related to activities and region.

(c) Contribution from liming and other natural events

Agricultural lime (aglime) in the form of crushed limestone (CaCO3) and crushed dolomite ($MgCa(CO_3)_2$) are applied to agricultural soils to increase soil pH. Following the supposition by IPCC that all C in aglime is eventually released as CO_2 to the atmosphere, the CO2 emissions from addition of carbonate limes to soils are estimated based on amount (M_x) and default emission factors (EF_x) of CO_2 for two major types of

9 IPCC Guidelines for National Greenhouse Gas Inventories, Chp. 11, 2006

aglime i.e. limestone and dolomite. The Annual C emissions from lime applications, tonnes C yr^{-1} denoted as CO_2-C *Emission* is estimated as follows:

$CO_2\text{-C } Emission = (M_{Limestone} * EF_{Limestone}) + (M_{Dolomite} * EF_{Dolomite})$ (Equation 2)

There are two other sources of emission during the agriculture stage namely emission from residue degradation in the field, and emission from soil. Contribution from residue degradation is estimated based on change in carbon stock change and emissions resulting from natural decay or burning during land clearing. However only CH_4 and N_2O, released during these activities is absorbed into the GHG accounting for agriculture activities as CO_2 is emitted is considered neutral.

(d) Emission from soil

Land conversion to cropland that entails intensive management will usually result in losses of C in soil organic matter and dead organic matter. IPCC Guidelines assumes any litter and dead wood pools should be assumed oxidized following land conversion and changes in soil organic matter.

$\Delta C_{LCSoils} = \Delta C_{LCMineral} - \Delta C_{LCorganic} - \Delta C_{LCLiming}$ (All parameters in tonnes C yr^{-1})

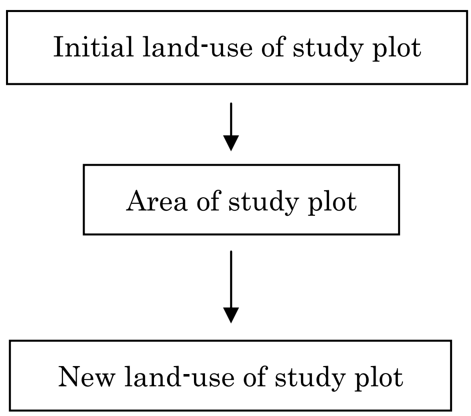
(Equation 3)

$\Delta C_{LCSoils}$ = change in carbon stocks in soils in land converted to cropland

$\Delta C_{LCMineral}$ = change in carbon stocks in mineral soils in land converted to cropland

$\Delta C_{LCorganic}$ = C emission from cultivated organic soils converted to cropland

$\Delta C_{LCLiming}$ = emissions from lime application on land converted to cropland



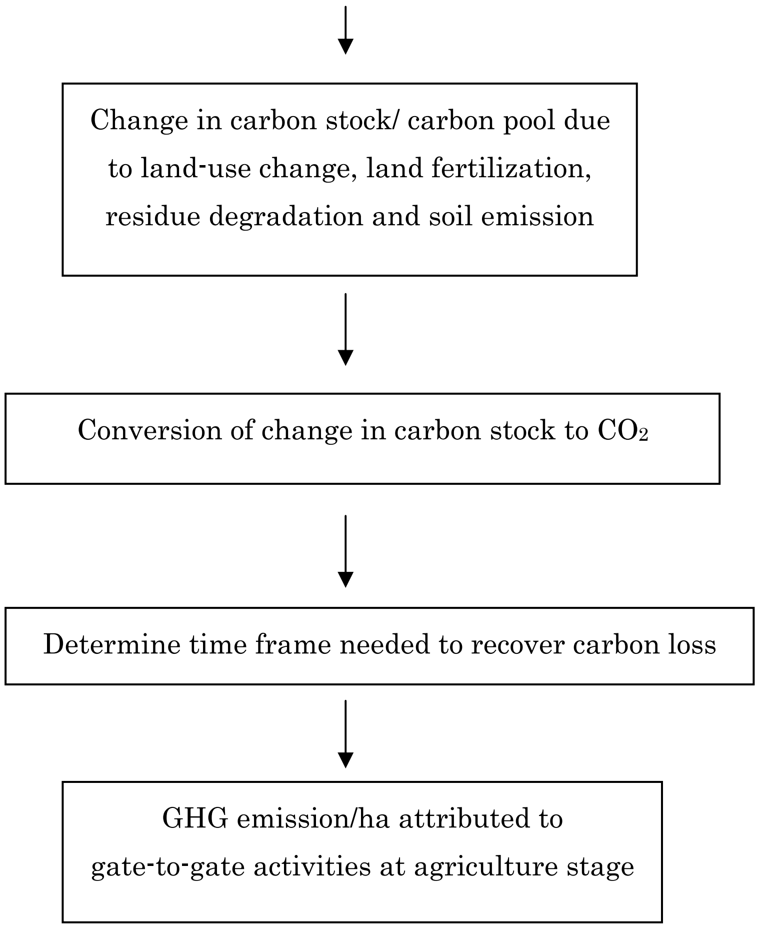


Figure 3-1-3: Flow diagram of data acquisition required to calculate the GHG emission related to land-use and crop management of biomass feedstock materials.

Although a laborious process, the GHG inventory related to agricultural activities beginning with land preparation such as Land Use and Land-Use Change (LULUC) has been viewed as a significant contribution to GHG emission in the cultivation of biomass feedstock material. Its' inclusion in the GHG-LCI of bioenergy is necessary to ensure the carbon footprint values calculated according to this guideline is considered credible. Figure 3-1-3 summarises the steps for estimating the GHG emission for production of biomass feedstock.

In completing the LCI for agriculture stage, emissions related to the production of materials, chemicals, conventional fuels and other manufactures, including fuel for transportation are included, as is normally calculated in the LCA methodology.

(ⅱ) **Processing, Conversion, Transformation and Utilisation Stages**

The GHG emissions from the production processes generally differ by technologies, efficiencies and management practices. Direct measurements for input and output data are more readily available and less complex than the agriculture stage. Irrespective of the technologies and processes, GHG inventory:

- Resource consumption: fossil fuels, minerals, water, chemicals
- Electricity consumption
- Air pollution (including GHGs) emissions
- Wastewater discharge
- Solid waste generation

Within this product system is the emission from transportation and distribution. Emission from open ponding treatment system may require more tedious measurement to obtain average data. In general, an appropriately structured questionnaire will guide collection of input and output data relevant to develop the LCI of a type of bioenergy from agriculture to the biofuel production stage. The end-of-life stage for biofuel is not included in the LCI as burning of biofuel whether for transportation or power generation is considered CO_2 neutral.

3.1.3 Recommendations

The drivers for the development of Biomass Utilisation as Bionergy in East Asia have been energy security and development of a potential new economic sector. In this respect, environmental criteria of biomass derived fuel has not been emphasised greatly unless required by the export market. Environmental aspects should be given due attention with the rapid expansion of bioenergy, in particular life cycle GHG profile or carbon footprint.

Eight recommendations are forwarded as a result of the ERIA sponsored project on "Investigation on Guidelines for Life Cycle Green House Gas Calculation in the Utilisation of Biomass for Bioenergy".

(i) LCA is a relevant tool to develop the GHG profile or carbon footprint of bioenergy

LCA is one of the relevant methodologies, which can assist policy makers to establish the significance of environmental issues in relation to economical and social factors. The cradle to grave approach incorporates contributions from every source in the bioenergy pathway including emissions from the use of fossil fuels at some stages of the life cycle and also land-use change.

Although the full LCA methodology is not needed since the LCI phase is sufficient to quantify the GHG profile of bioenergy, it is recommended that the implementation of the LCI phase be carried out in accordance with ISO 14040 and ISO 14044 as far as is practicable. Justification should be given for deviation from the standard recommendation.

(ii) Issues on land-use

It is recommended that the six land-use categories introduced by IPCC be adopted by all member countries namely forest land, cropland, grassland, wetland, settlement and other land. This adoption is required to enable comparison of GHG profile of bioenergy from land-use change perspective. However it is pertinent that East Asia establish data on the type of land-use prevalent in the region, including land-use change such as logged over and secondary forest that are being converted to cropland. In spite of the high uncertainty associated with the IPCC emission factors, they will still be used until regional or local data are obtained scientifically.

(iii) Indirect Land-Use Change

There are increasing pressures from some legislative framework, especially from EU to consider indirect land-use change when computing the GHG profile of a bioenergy. Direct land-use change occurs as part of a specific supply chain while 'indirect' land use change is a consequence of market forces. Proposed methodologies that quantify GHG emission related to indirect land-use change modify the conventional LCA technique and contain attributes that are more policy-based than science-based. The approach does not fall under the LCA methodology prescribed by the ISO standard and should not be included in the life cycle inventory.

(ⅳ) Peatland Management

In recent years, land-use change for conversion of peatland into cropland such as oil palm plantation has been hotly debated in particular on the potential magnitude of GHG emission. While there is little agreement on emission rate of GHG from converted peatland due to limited measured data, it is accepted that drainage of peatland for agriculture purpose does potentially reduce a carbon reservoir. In view of the existence of substantial areas of peatland in some parts of East Asia, it is recommended that any effort to increase understanding of the CO_2 flux of peatland should be highly supported.

(ⅴ) Carbon sequestration/ capture

IPCC estimates GHG emission from carbon stock change based on rates of carbon losses and gains by a given area of land-use change according to equation herewith:

$$\Delta C = \sum_{ijk} [A_{ijk} * (C_I - C_L)_{ijk}] \quad \text{(Equation 4)}$$

ΔC = carbon stock change in the pool , tonnes Cyr^{-1}

A= area of land, ha

ijk = corresponds to climate type *I*, forest type *j*, management practice *k* etc.

C_I = rate of gain of carbon, tonnes C $ha^{-1}yr^{-1}$

C_L = rate of loss of carbon, tonnes C $ha^{-1}yr^{-1}$

The default assumption in the IPCC Guidelines is that carbon removed in wood and other biomass from forests is oxidised in the year of removal and have provided a rather complicated approach for their conversion to wood products, existing as biogenic carbon or stored carbon. In this respect, PAS 2050 has sought to address this stored carbon or biogenic carbon by assigning a 100-year period of storage.

Since carbon capture or sequestration has a significant impact on the life cycle footprint of biomass derived energy, it is important that this carbon removal cycle at the feedstock supply stage be studied and any principles to be proposed must represent the East Asian region. The importance of biogenic carbon introduced by PAS 2050 is relevant to the development of the GHG estimation system for East Asia especially felled biomass that are not used as fuel but transformed into panels and furniture.

(vi) Reference data/ values at regional level

Development of a regional database on LCI data for bioenergy would assist the carbon footprinting of bioenergy. For example the European Reference Life Cycle[10] Database (ELCD) has under its Energy section data sets on electricity, fuels, thermal energy and pressurised air that can be used quite appropriately for anyone doing LCA within the EU region.

Similarly developing and transition countries of East Asia would require background data and conversion factors to enable them estimate life cycle data of GHG emission or release. The data sharing will also enable some form of standardisation among the 16 countries such as terminologies, methodologies, cut-off criteria, time frame (including for annualising) and fundamentals such as form of reporting, functional units, allocation principles, carbon offsets and capture.

(vii) Tier Approach to Data Collection

It is proposed that data collection follow the IPCC three methodological tiers for estimating GHG emissions and removals by each contributing source. Tiers correspond to a progression from the use of simple equations with default data to country-specific data in more complex national systems. The three general tiers are briefly described in Table 3-1-2.

[10] M.A.Wolf et.al., Meeting Among Int. Partners on The International Reference Life Cycle Data System, Nov. 2008, JRC European Commission

Table 3-1-2: Summary of the Three Tier Levels for Estimation of GHG Emissions for Landuse Change[11]

Tier 1	o Applies equation 3 for changes in two carbon pools namely 'aboveground biomass' and carbon in the top 0.3 m of the soil o Carbon accounting required only for wood harvested as biofuels for estimating non-CO_2 gases. o Use default emission factors provided by IPCC (until East Asia values are established). o Use activity data that are spatially coarse, such as nationally or globally available estimates of deforestation rates, agricultural production statistics, and global land cover maps.
Tier 2	Same methodological approach as Tier 1 but applies emission factors and activity data that are country-specific including specialised land-use categories.
Tier 3	Higher order methods are used including models and inventory measurement systems tailored to address national circumstances, i.e. detailed country-specific data. Provides estimates of greater certainty than tiers 1 and 2.

(viii) Reporting vs Targets-Setting

The GHG profile that is eventually calculated should not include offsets for fossil fuels replacement nor report in terms of carbon payback period. Comparative performance based on the GHG profiles of different bioenergy is one of the approaches to encourage improvement of production of feedstock materials, e.g. improved plantation management practices, and improved processing technologies that will reduce use of fossil fuel through energy efficiencies and waste minimisation, including utilisation of process wastes.

For comparative performance, a number of functional units such as kg CO_2/MJ of the fuel should be made available for objective evaluation among different forms of bioenergies and their production methods.

[11] IPCC Good Practice Guidance for Land Use and Land-use Change and Forestry

3.2 ECONOMIC IMPACT - Methodologies Used in the Calculation of Indices for Economic Assessment -

3.2.1 Introduction

Economic sustainability of biomass utilisation relates to the exploitation of biomass resources in a manner by which the benefits derived by the present generation are ascertained without depriving such opportunity to the future generation. In the assessment of sustainability, it is equally important to determine the actual level and degree of the economic benefits brought about by the biomass industry. Specific economic indices would have to be taken into consideration to measure the scope of the benefits. Existing methodologies in quantifying such indicators would have to be adopted and evaluated as well. Economic indicators ultimately provide for an accurate measurement of the economic performance of a particular industry such as biomass.

Previous studies have identified a number of benefits arising from biomass production and processing. For instance, a number of studies have described and estimated these impacts as follows. An article published at the Geo-energy website dated 2005 mentioned that the U.S. geothermal industry supported some 11,460 full time jobs in 2004. Tax revenues from geothermal activities amounted to $12 million supplying 25% of the tax base for a rural town in California. Other economic contributions mentioned in the article were reduction in foreign oil imports, price stability, and fuel supply diversification. The American Solar Energy Society cited that renewable energy and energy efficiency industries created a total of 8.5 million jobs in 2006 throughout the United States. A case study in Columbia County accounted for 170 full time jobs during construction and 39 full time permanent operations jobs generated by the existing wind facilities. Additionally, wind facilities contributed $1.3 million in annual tax revenues. In 2008, an article about the benefits of landfill gas energy stated that cost savings which can be translated to millions of dollar savings could be realized through the replacement of expensive fossil fuels by landfill gas use. In an article entitled "Rural communities can gain big economic benefits from wind energy" in 2001, it was pointed out that wind farms on rural land can earn more money per acre for farmers and ranchers than many traditional agricultural activities.

Based on the various literature reviewed, the most common economic contributions of biomass utilisation are value addition, job creation, tax revenue generation, and foreign trade impacts. The same indicators were taken into consideration in establishing the guidelines in economic impact assessment specifically for this study.

3.2.2 Economic Assessment of Biomass Utilisation

(i) Gross Value Added or Total Profit before Taxes

Value addition refers to the increase in worth of a biomass product in terms of profit by undergoing certain processes or conversion to come up with a marketable energy product. Gross value added, as used in this study, is the sum of the value addition or net profit before tax generated out of the main product and the by-products from conversion or processing. The following equation was adopted to compute value addition:

$GVA = VA_a + VA_b$; where,

VA_a – value added from main product

VA_b – value added from by-products

The value added for both the main products and the by-products can be computed using the following equation:

$VA_a = GR_a – TC_a$; and,

$VA_b = GR_b – TC_b$; where,

GR – Gross or Total Revenue

TC – Total Cost

a – Main Product

b – By-products

Quantifying gross revenue was relatively easier as compared to quantifying the total cost. Gross revenue is simply the product of price and quantity (applies to both main product and by-products). Total cost, on the other hand, was calculated in every stage of the conversion process – from the initial up to the final product. This can be better illustrated by dividing the cost calculation into three stages. First stage is regarded as the *Production* stage. This stage accounts for the costs incurred in the actual production process of the raw material or initial product. The costs associated in this stage can be collectively described as the farming costs. The formula adopted is as follows:

TC = Direct Costs + Indirect Costs; where,

Direct Costs – Planting material, fertilizer, direct labor (hauling, transplanting, weeding, fertilizing, and other maintenance operations)

Indirect/Other Costs – Land preparation, harvesting, transportation

The second stage can be termed as *Primary Processing*. 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. The costs associated in this stage can be distinguished as the extraction costs. The following equation was used for calculation:

TC = Direct Costs + Indirect Costs; where,

Direct Costs – Costs of raw material, direct labor

Indirect/Other Costs – Administrative costs, utilities such as electricity and water, miscellaneous overhead such as helper, fuel, fees and local taxes and loan interest, selling cost such as depreciation of fixed assets, and trucking

The third stage is *Secondary Processing*. From the readily convertible material in the second stage of production, certain processes such as esterification are undertaken to produce the final product which is biodiesel. The costs associated in this stage can be referred to as the biodiesel production costs. Total cost was computed as follows:

TC = Direct Costs + Indirect Costs; where, Direct Costs – Raw material costs, Direct operating labor

Indirect/Other Costs – Plant maintenance and repair, operating supplies, utilities, fixed charges such as depreciation, property taxes and insurance, and plant overhead costs

(ⅱ) Employment

Job creation is another indicator for assessing the economic impact of the biomass industry. In a study concerning the sustainability criteria and indicators for bioenergy, it was cited that one of the possible indicators for job creation is the number of jobs or position per unit of energy produced throughout the entire chain of production. The same concept was adopted by this study in determining the employment impact of the biomass industry. The number of jobs generated with the presence of the energy project was computed as follows:

Employment = Total Production x Labor Requirement for every unit produced

In most cases, labor requirement is expressed in terms of mandays. As such, necessary conversion may be done to express mandays into number of persons hired. The resulting figure is a more concrete representation or estimation of the employment impact.

(ⅲ) Tax Revenues

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. For instance, take into account the coconut industry of the Philippines as the biomass industry under consideration. Mature coconut (*Production* stage) is processed into copra. Copra is then processed into coconut oil (*Primary Processing*). Finally, coconut oil is processed into the final product – coconut methyl ester (*Secondary Processing*). Taxable sectors of the industry may include the farmers and the various sectors in the production chain. However, under the Philippine agrarian reform program, farmers are exempted from paying taxes. Therefore, tax-generating sectors include those players under the primary and secondary processing stages only. The total taxable income under these stages of production shall be multiplied by the prevailing tax rate to obtain the actual amount of tax revenues. This can be further illustrated by the following equation:

Tax = Total Taxable Income x Tax Rate; where,

Total Taxable Income = income from main product (profit per unit x volume) + income from by-product (profit per unit x volume)

(ⅳ) Foreign Exchange

Biomass production and processing has positive effects on foreign trade which is determined by two factors, foreign exchange earnings and foreign exchange savings. Foreign exchange earnings arise from the gains of exporting the readily convertible material for biodiesel production. As in the Philippines, the exportable input to biodiesel production is coconut oil. Even before the advent of the biofuel industry, the country is already benefiting from coconut oil exports – one of its major dollar earners. This could likewise be the case for other countries producing biodiesel such rapeseed oil, palm oil, and others.

Foreign exchange savings can be accumulated from reduced diesel imports with the presence of the energy project. Since biodiesel is expected to at least displace if not replace a fraction of the overall diesel consumption of an economy, eventually imports will decrease. For both foreign exchange earnings and savings, the methods of computation are as follows:

Foreign Exchange Earnings = Price per unit of convertible material x Total volume of exports

Foreign Exchange Savings = Amount (in weight) of biomass x Density of biomass x Forex savings per diesel displacement

In the event that portions of the convertible material are both exported and consumed locally for biodiesel production, a tradeoff occurs. A fraction of the exportable amount would be diverted as input to biodiesel production. As a result, foreign exchange earnings would be reduced. The net effect of this tradeoff or net foreign exchange (Forex) earnings is valuated as follows:

Net Foreign Exchange Earnings = Reduced Forex Earnings + Forex Savings

(v) Total Value Added to the Economy

Total value added 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; tax revenues collected from the different key players of the biomass industry; foreign exchange earnings from exporting the readily convertible material for biodiesel production and foreign exchange savings from reduced diesel imports with the presence of the biomass energy project. The formula is:

Total value added to the economy = net profit after tax + wages and salaries paid + tax revenues + net forex earnings

where net profit after tax is equal to net profit before tax less tax revenues. The formula can be written as:

Total value added to the economy = net profit before tax + wages and salaries paid + net forex earnings

The economic indices, along with the methods of computation enumerated in this section, serve as guidelines in assessing the benefits brought about by biomass production and processing. This study aims to quantify the level and degree of the economic benefits by imputing actual values to provide a concrete overview of such benefits. Consequently, policymakers could have a grasp as to what aspects of the biomass industry are to be addressed in accordance with the purpose of boosting the national economy. A more important case in point is that biomass utilisation practices must gear toward achieving economic sustainability.

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3.3 SOCIAL IMPACT

3.3.1 Introduction

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

Measurement of social development significantly differs from economic development. Also, compared to social indicators, a plenty of economic indicators are more frequently available for all countries. But in many cases, particularly in case of some developing economies, they reflect a rosy picture which is far away from the reality. For example, looking at the GDP growth rate, India is one of the fastest growing country in the world, but country's social devlopment indicators fall way behind even many small economies. To capture the holistic picture of development across countries, the UNDP has used the Human Development Index (HDI). This essentally take into account the measures for Per Capita Income, Life Expectancy and Literacy. However, it is to be noted that while development of these indices using UNDP system is well defined and uniformly applied to all countries, some of the factors, which could be either region specific for East Asia or country specific for any country within this region need to be considered differently. Further, development of bioenergy has different factors, such as technical, social, economic and policy, for various regions. Hence, using the same yard-stick for assessing the sustainability of bioenergy for all regions of the world may be incorrect.

This section focuses on methodology for estimating social impacts of biomass utilisation for energy production. Taking a case study of biodiesel production from jatropha plantation in India, estimation of social development indicators (SDIs) are made. The methodology suggested here could be helpful in developing guidelines for sustainability of biomass energy in the East Asia region.

3.3.2 HDI and Social Development

As per the UNDP system, the main indicator of social development is Human Development Indicator (HDI), which essentially 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 US dollars. 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 3-3-1.

Table 3-3-1: 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	$40,000

Source: **UNDP**

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

(i) 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) and it measures the relative achievement of a country in life expectancy at birth.

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

(ii) 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 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.

$$\text{Education index} = \frac{2}{3} \times \text{ALI} + \frac{1}{3} \times GEI$$

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

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

(iii) GDP Index

GDP Index (GI) is calculated using adjusted GDP per capita (PPP US$). 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 United States dollars.

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

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

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

3.3.3 Estimation of SDIS

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 comprehensive data sets for the region where biofuel crops cultivation has been taken up. The data should contain farm level information on production of biofuel crops (such as jatropha, sugarcane, palm, coconut, etc.) and information throughout the value added chain during the whole life cycle of biodiesel production. Considering these facts, this study uses secondary data on waste land in each state of India that are planning jatropha cultivation and which are potentially fit for this biofuel crop. Two micro level data sets have been used to calculate the values of HDI and project them to national level.

3.3.4 Data and Assumptions

Some of the points about the data used for estimation of SDIs and assumptions made are as follows.

- Secondary data give information about the planned cultivation of jatropha or planned production of biodiesel. But in order to calculate the exact impact, the actual data on area under jatropha cultivation and biodiesel production should be considered rather than projected.
- Selection of control group is really difficult, as we need to consider two areas which have same climatic condition, same socio-economic structure and above all successful implementation of jatropha cultivation. This is only possible by conducting a primary pilot survey in such areas.
- For calculating the social impact of jatropha cultivation, the data are available for income generation only. But subsequent relationship between income and life expectancy/education 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, 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 jatropha intervention.

3.3.5 Methodology for Estimation

Considering the above limitations of data, social development indicators (HDI and GDI) at micro (district level) and macro (state level) are calculated, which could also be used to project SDIs at India level. In this study a "bottom-up approach" has been followed to estimate the effective social returns on bioenergy production. Two potential districts are identified in India, namely, Adilabad in the state of Andhra Pradesh and Ahmednagar in the state of Maharashtra. The statistics of Jatropha cultivation in these districts is given in the Appendix 1 (Table A). The steps (1 to 8) used to calculate the SDIs at micro and additional steps (9 to 10) are used to project SDIs at macro level are mentioned below.

Step 1: *Calculation of direct employment from jatropha cultivation.*

The direct employment for any district say, A, includes persons employed in site preparation, jatropha plantation and post plantation work. For this district employment in person days per hectare is calculated for consecutive 5 years.

Step 2: *Calculation of indirect employment from jatropha cultivation and biodiesel production.*

This 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 hectare of jatropha crop.

Step 3: *Aggregating the cost of direct and indirect employment.*

This is done by taking minimum wage determined by International Labour Organization (ILO) and area concerned and summing the cost of steps 1 and 2. This gives us total cost per hectare of jatropha cultivation and total cost per ton of biodiesel production. The conversion factors used here is that "1 hectare of jatropha cultivation produces 1892 litre of biodiesel and 1 ton of biodiesel = 1267 litre." For calculating cost per ton of biodiesel production, the same 5 years' term is taken for cost calculation as in the case of calculating cost per hectare of jatropha cultivation. The calculations of employment in terms of cost and person days are shown in Appendix 1 (Table B).

Step 4: *Calculation of GDP (PPP) per capita*

For calculating GDP (PPP) per capita, data from step 3 (say, Rs. X / ha of jatropha) or (Rs. Y / ton of biodiesel) are used to calculate total income generated from Z ha of land. Therefore, Rs.(XZ) or Rs.(YZ) is divided by total population of the area plus actual GDP of place which gives GDP (PPP) per capita. It can be suitably converted into US dollars

($) to ease the calculation of HDI.

Step 5: *Calculation of HDI*

The HDI can be calculated as HDI = 1/3(LEI+EI+GI)

where, LEI: Life Expectancy Index (data taken from the area).

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

ALI: Adult Literacy Index (data taken from the area).

GEI: Gross Enrolment Index (data taken from the area).

GI: GDP index ($) will be given by

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

Where, actual value is taken from step 4 above. Then, HDI calculation may be made either by taking into account of Rs. per hectare of jatropha cultivation or Rs. per ton of biodiesel production.

Step 6: *Calculation of 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, namely, life expectancy index, education index and GDP index are calculated separately for men and women, as done in the step 5 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. For calculating equally distributed index for three indices the following formulae is used.

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

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 7: *Calculation for the other district, Say B*

Step 1 to 6 is repeated for the other district.

Step 8: Calculation of c*hange in HDI*

Average of HDI for district A and district B gives the HDI that incorporates jatropha cultivation. The change in HDI can be calculated by subtracting current HDI for India, which is 0.609 (HDR, 2008).

Based on the above method, the change in HDI for per hectare of jatropha cultivation and per ton of biodiesel production is given in the Appendix 1 (Tables C and D).

Step 9: *Projection of population (male and female)*

The data on actual population for India are available only for 2001 (Census, 2001 data). But other data such as cultivation area, literacy rate, etc. are available for the year 2008. This required population projection for the year 2008 assuming a constant exponential growth rate. Same process is repeated for male and female population taking growth rate constant. Then, the share of male and female population is calculated.

Step 10: *Calculation of HDI and GDI for jatropha cultivation and biodiesel production.*

For macro (state) level calculations the same method is followed as discussed for the micro (district) level. HDI and GDI for jatropha cultivation and biodiesel production were calculated separately.

Finally, overall HDI is calculated by taking average of all states and union territories, and then to find change in HDI = 0.609 (value of HDI for India in 2008) is subtracted from the given value. This gives changes in HDI due to jatropha intervention.

The values of HDI for various states, both in terms of jatropha cultivation and biodiesel production, and the values of GDI are given in the Appendix 1 (Table E).

3.3.6 Summary of Results

This section suggests guidelines for estimating Indicators of Social Impact of

Biomass Utilisation in East Asia. A method of calculating the change in SDIs, due to bioenergy production in India, is mentioned that may be useful for developing guidelines for the East Asian region. In biodiesel production, plantation of jatropha will be the most dominant item of expenditure. It is estimated that an employment of 123 person days per hectare of jatropha plantation in the first year and 322 person days in five years will be generated.

To calculate the change in SDIs, both micro (district) and macro (state) level cases are considered. The case study of Adilabad district of Andhra Pradesh indicates that overall monetary gains, due to employment generation, for the region will be Rs.4221360. The GDP (PPP) per capita with the jatropha intervention and other existing factors gives a value of Rs.21224. This gives a GDP index of 0.420 and fitting the data of life expectancy and education gives a HDI value of 0.647. Thus, the change in HDI is 0.038 (0.647-0.609), where, 0.609 is the value of HDI for India in 2006, as per UNDP estimates. Similarly, the change in HDI when biodiesel production is taken into account comes out to be 0.038. The GDI for Adilabad district is 0.518 in case of only jatropha cultivation and 0.537 for biodiesel production, which is 80% and 82.9% of HDI, respectively.

The case study of Ahmednagar district indicates a total monetary gain for the region, due to the employment generation as Rs.23544562. The GDP (PPP) per capita, with jatropha intervention and other existing factors gives a value of Rs.18054 and a GDP index of 0.376. Fitting the data about life expectancy and education, the HDI for Ahmednagar for jatropha cultivation only comes out to be 0.617. Hence, the change in HDI is 0.008 (0.617-0.609). However, taking into account biodiesel production, HDI is 0.647, which is much higher than the results coming only from jatropha cultivation. Ahmednagar GDI is 94.8 % of HDI when only jatropha cultivation is considered and it is 92.8% of HDI taking into account of biodiesel production.

The aggregate HDI of states (macro level) due to Jatropha cultivation, considering other development indicators constant, comes out to be 0.621. Therefore, the change in HDI due to jatropha cultivation is (0.621-0.609=0.012). Similarly, when biodiesel production is taken into consideration then the total HDI for India comes out to be 0.622, giving a positive deviation of (0.622-0.609=0.013). The GDI value for India is projected as 0.571 which is 91.8 % of the HDI.

3.3.7 Conclusions

A case study of jatropha cultivation in two districts of India indicates that geographical location and field conditions have tremendous effect on survival rates of jatropha plants. Under adverse conditions, survival rate of jatropha plant are very low. On the other hand, some other native oil trees such as Pongamia and Neem may hold promises better. Estimations of HDI due to jatropha cultivation and biodiesel production indicate that the HDI change in whole life cycle of biodiesel production is higher than only in jatropha cultivation.

This study is based on secondary data and to calculate exact change in SDIs, actual data at microscopic level (such as village) are needed. Hence, it is suggested that in the next phase of the project a pilot study on "Estimation of Social impact of Jatropha and other Oil Trees cultivation for Bio-diesel Production in India" is taken up. The pilot study should focus on collecting data and information through survey of various stakeholders involved during various stages of jatropha cultivation and bio-diesel production. Data should be collected through a questionnaire administered to various focus groups. A combination of interview techniques such as face-to-face personal interview, discussion on telephone, correspondence through email, fax and normal mail, etc. will be used for collecting the data and information. A draft of the questionnaire on social issues proposed for the pilot study is given in Appendix [3].

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Appendix 1: Calculations of HDI

Table A: Jatropha cultivation in Adilabad (AP) and Ahmednagar (MS)

Particulars	Adilabad	Ahmednagar
Sample Village (No)	7	10
Area Proposed (ha)	380.4	2025.6
Area Covered (ha)	312.0	1091.6
Jatropha sown (No.)	1358070	4960230
Plant density (per ha)	4353	4544
Survival (%)	2.19	2.96

Source: GFU, 2005

Table B: Employment from jatropha cultivation and Oil production

S.No	Item	Cost (Rs.)					Employment In person days				
		Year					Year				
		1st	2nd	3rd	4th	5th	1st	2nd	3rd	4th	5th
Direct Employment from Jatropha Cultivation											
	Site Prepartation										
1	Cleaning & Levelling	1100	0	0	0	0	10	0	0	0	0
2	Alignment & Staking	550	0	0	0	0	5	0	0	0	0
3	Digging of Pits	5500	1650	0	0	0	50	15	0	0	0
	Plantation		0								
4	Planting & Replanting	2750	550				25	5	0	0	0
	Post Plantation		0								
5	Irrigation	550	330	330	330	330	5	3	3	3	3
6	Fertilizers	220	110	110	0	0	2	1	1	0	0
7	Pesticides	220	110	110	110	110	2	1	1	1	1
8	Weeding & Soil Working	2200	2200	2200	2200	2200	20	20	20	20	20
Employment Post Harvest											
9	Seed Collection	0	0	0	0	4400	0	0	0	0	40
10	Oil Extraction	0	0	0	0	2200	0	0	0	0	20
11	Transportation	220	0	0	110	550	2	0	0	1	5
12	Others	220	220	220	220	1100	2	2	1	2	10
	Total	**13530**	**5170**	**2970**	**2970**	**10890**	**123**	**47**	**26**	**27**	**99**

Table C: HDI Change based on Area of Jatropha under Cultivation

Item	Adilabad	Ahemednagar
Total Area for Jatropha Cultivation (ha.)	312	2025.6
Total Income (Rs.)	4221360	23544562
GDP/Capita	2.315607 (Due to Jatropha Cultivation)	7.169477
GDP/Capita(Purchasing Power Parities)	21224.32 (Overall)	18054.17
GDP Index	**0.420472**	**0.376618**
Life Expectancy Index	**0.866667**	**0.966667**
Literacy Index	0.645	0.546
Gross Enrolment Index	0.673	0.433
Education Index	**0.654333**	**0.508333**
HDI	**0.647157**	**0.617206**
Change in HDI (Due to Jatroopa Cultivation)	**0.038157 (HDI - 0.609)***	**0.008206 (HDI - 0.609)***

*Note: HDI for India in 2006 = 0.609 (HDR, 2008): India ranked 132nd in 179 countries (in comparison to HDI in 2005 = 0.619 and a rank of 128th in 177 countries)

Table D: HDI Change based upon Biodiesel Production

Item	Adilabad	Ahemednagar
1 (ha.) of Jatropha cultivation produces	1892 (L) = 1.493291 (ton.) Biodiesel	1892 (L) = 1.493291 (ton.) Biodiesel
1.493291 (ton.) requires (in 5 years)	35530 (Rs.)/ha. 23793.08 Rs./ton/ha	30429 (Rs./ha) = 20377.14
Total Area for Jatropha Cultivation (ha.)	312	2025.6
Total Income (Rs.)	7423441	41275928
GDP/Captia	4.072093 (Due to oil Production)	22.64171
GDP/Captia (Purchasing Power Parities)	21226.07 (Overall)	21244.64
GDP Index	**0.420494**	**0.420731**
Life Expectancy Index	**0.866667**	**0.866667**
Literacy Index	0.645	0.645

Gross Enrolment Index	0.673	0.673
Education Index	0.654333	0.654333
HDI	0.647165	0.647244
Change in HDI (Due to Oil Production)	0.038165 (HDI - 0.609)*	0.038244 (HDI - 0.609)*

Table E: HDI and GDI for various States of India

States	Projected Area (ha.)	HDI (Jatropha Cultivation)	HDI (Biodiesel Production)	GDI
Andhra Pradesh	600000	0.620050933	0.620546043	0.568213
Arunachal Pradesh	3000	0.619392242	0.619392869	0.568512
Assam	22000	0.619555337	0.619679358	0.569855
Bihar	195000	0.619545571	0.619662222	0.567756
Chhattisgarh	1000000	0.619874532	0.62023822	0.56964
Goa	60000	0.620132018	0.620687294	0.569279
Gujarat	16000	0.619489263	0.61956337	0.568421
Haryana	1750	0.619397324	0.619401806	0.568249
Himachal Pradesh	45000	0.619530812	0.61963632	0.56759
Jammu & Kashmir	100	0.61939217	0.619392744	0.567874
Jharkhand	300000	0.620018082	0.620488772	0.568383
Karnataka	240000	0.620082686	0.620601376	0.568212
Kerala	60000	0.61940654	0.61941801	0.567896
Madhya Pradesh	1000000	0.619640267	0.619828293	0.568074
Maharashtra	60000	0.619402369	0.619410677	0.567511
Manipur	2000	0.619392059	0.619392549	0.567337
Meghalaya	100	0.619391425	0.619391434	0.568043
Mizoram	500	0.61939148	0.619391531	0.56803
Nagaland	10000	0.619814604	0.620133479	0.570998
Orissa	2000000	0.660555498	0.679139551	0.611049
Punjab	300000	0.619417863	0.619437918	0.56747
Rajasthan	220000	0.619419383	0.619440588	0.567604
Sikkim	1000	0.619396401	0.619400183	0.567618
Tamil Nadu	40000	0.623656067	0.62668608	0.572089
Tripura	200	0.619391456	0.619391488	0.566688
Union Territories	50000	0.619392068	0.619392564	0.620186
Uttar Pradesh	1586000	0.619561951	0.619690963	0.567526
Uttranchal	200000	0.620754094	0.621765931	0.568612
West Bengal	4000	0.619466843	0.61952399	0.568932

4. INTEGRATION OF SUSTAINABILITY INDICATORS

4.1 Approaches for integration

Indicators are useful for presenting relatively complex situations in a simplified form to facilitate understanding. The previous chapter introduced indicators for assessment of the environmental, social and economic performance of biomass utilisation systems. Within each category, several parameters were needed for assessment. So, for sustainability assessment of biomass utilisation systems, a suite of indicators need to be considered. From the scientific point of view, such a system of indicators would be useful to make an overall assessment of sustainability. But from the point of view of communication as well as decision-making integration of the indicators is sometimes sought (Dahl, 1997). Clear-cut decisions are usually difficult to make based on a plethora of indicators; thus decision-makers would prefer to have a single index by which they can "unambiguously" evaluate a system to arrive at a decision. The 'pyramid of indicator sets' in Figure 4-1 displays the hierarchy of data to indices.

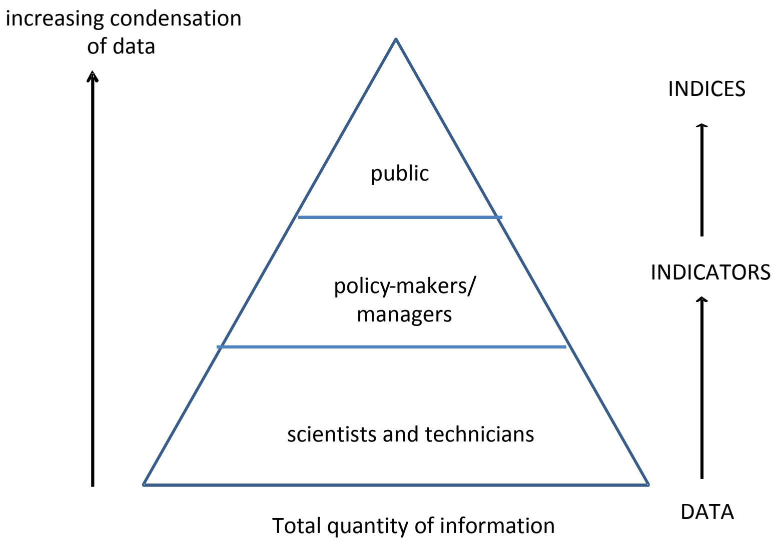


Figure 4-1: Relationship between indicators, data and information: the OECD 'pyramid of indicator sets' Source: Braat, 1991

High-level decision-makers are often unwilling to accept that something as complex as sustainable development can be represented adequately by a single index. The apparent "lack of ambiguity" associated with a single index is misleading as such an index is based on the inherent assumption that the indicators being integrated are actually tradable. Thus we are implicitly faced with the situation where we equate, for example, a ton of greenhouse gases with a certain number of jobs. This is the major reason why integration is not acceptable to many scientists and technicians; how meaningful is it to add up apples and oranges to a single number coefficient? On the other hand, even a moderately successful attempt at developing a small set of indices would at least encourage sustainable development goals to be included in policy and decision-making.

Integration of indicators is to be done at two levels – within the environmental, social and economic categories as well as across the three categories. Integration within a category has been done for environmental impacts in life cycle assessments using normalization and weighting techniques (Baumann and Tillman, 2004). Here, the various impact categories are normalized to a single unit, for instance person equivalents based on the impacts of an average person in a year and then weighting factors assigned based on the relative importance of the impact categories (which clearly can be quite subjective). Another approach has been to model impacts at the 'end-point' or 'damage' level relating environmental emissions to areas of protection such as human health, ecosystem quality and resources (Goedkoop and Spriensma, 2001). Yet again there are integration techniques based on monetization – money is a unit which is quite easy to understand for a varied audience. One major effort in this regard at the EU level was the ExternE project (ExternE, 2005). The underlying assumption with monetization of course is that everything can be monetized which apart from reservations based on scientific considerations also has strong ethical implications (Stirling, 1997). All the above integration techniques are numerical ones yielding a limited number of indices or a single index to facilitate decision-making.

Apart from the numerical integration techniques presented above, indicators could be kept entirely separate but presented together in a single table or diagram. This would be a visual integration that would facilitate looking at all the indicators together. One such technique, called the Dashboard of Sustainability, has been developed by a small group of indicator program leaders called Consultative Group on Sustainable Development Indices (CGSDI, www.iisd.org/cgsdi/). An analogy is drawn with a vehicle dashboard, with all its dials and lights, and sustainable development. Separate dials and warning lights are included for various dimensions of sustainability, so there is some disaggregation. The size of a segment reflects the relative importance of the issue described by the indicator, for example, the theme 'Economy' in Figure 4-2 has a weight of 45%. The colours indicate the level of evaluation, from green which is "very good" through yellow indicating "average" to red which means "crisis".

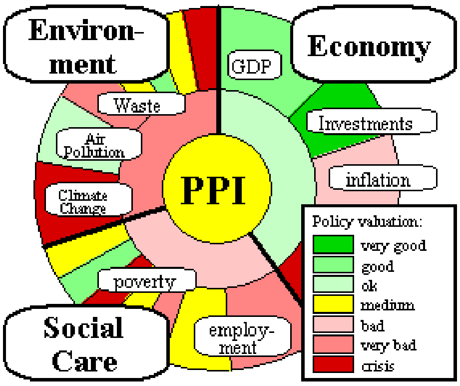


Figure 4-2: Dashboard of Sustainability screenshot (A number of indicators in the outer circle are combined to three sub-themes; the sub-themes are then condensed to a Policy Performance Index, PPI)
Source: http://esl.jrc.it/dc/pics/ppi_fut.gif

Another integrative approach is the use of an amoeba or radar diagram where indicators are arrayed as arms. It essentially comprises a bar graph of indicator values turned into a circular presentation. Figure 4-3 is an example of a radar diagram for assessing sustainability of buildings (Abeysundara et al., 2009).

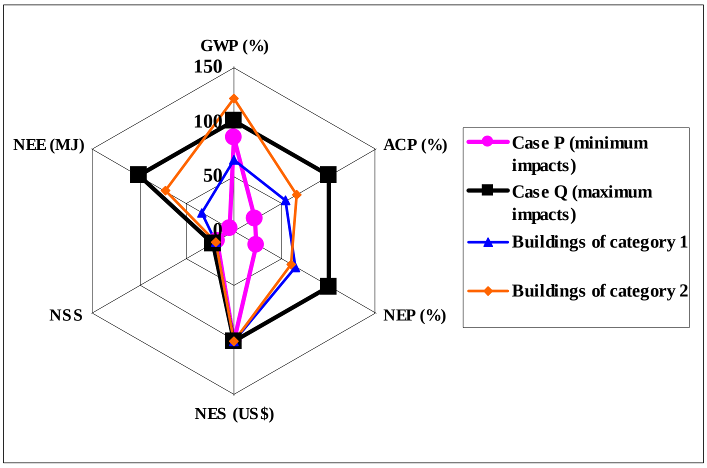
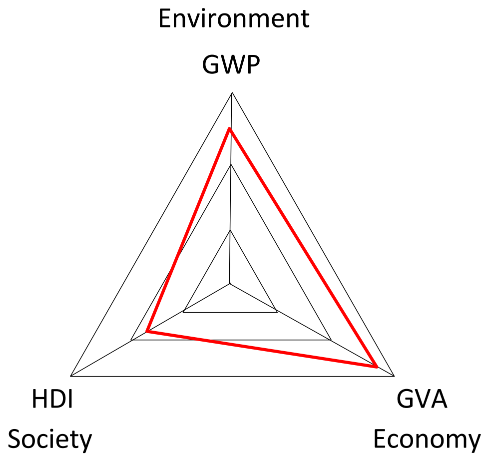


Figure 4-3: Environmental, economic and social scores of existing buildings with the cases that have minimum (P) and maximum (Q) impacts (NEE, NSS and NES refer to normalized embodied energy, social score and economic score respectively)
Source: Abeysundara et al., 2009

4.2 Integrated of indicators for assessing biomass utilisation

In the previous chapter, indicators have been proposed for assessing environmental, economic and social sustainability. For environmental sustainability, global warming potential has been proposed as the priority indicator in line with the current world effort in reducing greenhouse gas emissions. Of course this is not to trivialize other impacts on air quality, water resources, land use, biodiversity, etc. which must be considered too. For economic sustainability, gross value added and for social sustainability, the human development index (HDI) which is an aggregate index, have been proposed. These three broad indicators/indices could be easily presented in a radar diagram format shown in Figure 4-4 to give an overall visual effect of integration without actually aggregating them. Other impacts which are more qualitative in nature could be presented in a tabular form indicating current status and target to be achieved. Such an approach would address the need of policy and decision-makers for integration but at the same time having enough detail to allow transparency at the level of communication.



Other indicators	Target	Current status
Air quality		
Water use		
Others …		

Figure 4-4: Illustrative diagram for representation of sustainability

Further integration of the indicators for environmental, economic and social performance could be done numerically, if so desired, by setting target values of performance for each issue. Then, the values for each could be normalized based on the target value and aggregated based on a suitable weighting scheme formulated by the decision-makers based on their priorities. If the indicator values for environmental, economic and social performance are I_{en}, I_{ec} and I_{so} and the target values T_{en}, T_{ec} and T_{so} respectively; then based on relative weights of the three categories, W_{en}, W_{ec} and W_{so}, the single index would be:

$$\text{Sustainability Index} = \frac{\left(\frac{I_{en}}{T_{en}}\right)\cdot W_{en} + \left(\frac{I_{ec}}{T_{ec}}\right)\cdot W_{ec} + \left(\frac{I_{so}}{T_{so}}\right)\cdot W_{so}}{W_{en} + W_{ec} + W_{so}}$$

Such an index would be a fraction varying between 0 and 1 or could also be expressed as a percentage. The indicators could be suitably defined so that a higher value of the sustainability index would indicate a relatively more sustainable biomass utilisation scheme.

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5. POLICY RECOMMENDATIONS

This report on **"Guidelines to Assess Sustainability of Biomass Utilisation in East Asia,"** is based upon a study conducted during the second phase of the ERIA project. It builds upon the outcome of the first phase of the project entitled *"Investigation on Sustainable Biomass Utilisation Vision in East Asia."*

The study develops guidelines for sustainable biomass utilisation in the East Asian region. The objective of these guidelines is to facilitate biofuel policy formulation in the region that may be used at the stage of decision making. The study follows the CEBU declaration on the "East Asian Energy Security," collectively endorsed by the concerned political leaders, to promote sustainable production and consumption of biofuels in the region.

(i) Adopting of Pilot Studies

The results of this study are based on the secondary data, which highlight the planned or projected figures but do not depict the factual situation. It is suggested that, in the next phase of the project, some pilot scale studies should be taken up in the region, which would focus on collecting the actual data and information through field surveys of various stakeholders involved in biofuel programs.

(ii) Advancing Methodologies

Lifecycle GHG emissions are highly focused and based on some major international frameworks. However, several factors have a high degree of uncertainty to estimate the emissions. East Asian countries should develop and share common methodologies and necessary data to support scientific assessment.

(iii) Forming task team to cope with worldwide standardisation

East Asian countries should take into consideration the guidelines of ISO, GBEP, and similar other international organizations while implementing and enforcing their own policy framework developed for biomass utilisation. It is suggested that an expert working group be formed in East Asia, which meets regularly to discuss the relevant issues. Outcome of such discussions would be conveyed to the representatives of the member countries at various international forums.

6. CONCLUSION

The WG of ERIA, through an extensive research and elaborate discussions, developed the guidelines for "Sustainability Assessment of Biomass Utilisation in East Asia," which are based on the three pillars of sustainability i.e. social, economic and environmental perspectives. The WG members hope that this report would assist worldwide discussions on sustainable biomass utilisation and enhance understanding of the East Asian opinion and approach.

These guidelines will be tested with the help of some pilot scale studies on actual biomass utilisation projects to be conducted in 2009. The WG is planning to come out with the results of these studies and present them in an international workshop in 2010. The announcement will be uploaded on homepage of the ERIA. We invite the participation of individuals who would like to contribute to this effort.

QUESTIONNAIR

Appendix［1］ PILOT STUDY - ENVIRONMENT

Introduction

Life Cycle Assessment is a compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle (ISO 14040). The LCI data can be used to establish the environmental sustainability of the specific bioenergy with respect to green house gas emission and climate change.

In developing the LCI GHG database on Biomass derived bioenergy, ERIA Project Team seeks your cooperation to fill in the attached questionnaire to the best of your ability. The questionnaire has been divided into the various compartments of the life cycle of a bionergy beginning from:

- Feedstock supply (crop production/ cultivation)
- Processing/ treatment of feedstock material
- Intermediate conversion(s)
- Biofuel production
- Storage/ packaging
- Utilisation
- Transportation and distribution is needed for every stage as part of the product system

Not every stage is needed and conversion/transformation to the final form of the biofuel from the agricultural feedstock material can take more than one stage.

Ⅰ. GENERAL COMPANY INFORMATION

1.1. Name	
1.2. Address	
Phone	
FAX	
1.3. Name/position of contact person	
E-mail	
1.4. Type of biomass feedstock material:	
1.5. Completed by:	
1.6. Date of data compilation	

Ⅱ. Seedling Stage

2.1. Name of nursery	
2.2. Location	
2.3. Type of nursery	

2.4. No. of cycles/ year (single stage/ two stages etc.)	

2.5. Information on Nursery Management and Practices (Please provide figures or information for three consecutive years if available, otherwise approximate current figures are also acceptable)	
No. of bags/ per hectare	
200_	
200_	
200_	
General average	
Number of seedling / hectare	
200_	
200_	
200_	
General average	
Average success rate (seedlings to plant)	
Consumables consumption / year	

Consumable	200_	200_	200_	General average
Water (litre)				
Electricity (kWh)				
Diesel (litre)				

2.6. Data Treatment to Estimate Electricity Consumption Use of electric-powered equipment and systems	
No. of sprinklers/hectare	
Motor power of sprinkler, kW	

2.7. Data Treatment to Estimate Diesel/Fuel Consumption Transportation	
Distance, km	
Truck capacity, ton	
Actual load, ton	
Empty return	☐Yes ☐No
No. of trips/day	

2.8. Agrochemicals consumption / year				
Consumable	200_	200_	200_	General average
Fertiliser • Muriate of potash • ammonium nitrate • phosphate • ______________ • ______________ • ______________ • ______________ • ______________				

Pesticides • Methyl metsulfuron, isopropylamine, • ______________ • ______________ • ______________ • ______________				
• Others • ______________ • ______________ • ______________				

*Note: *Please fill in according to use*

Ⅲ. Plantation Stage Information on Plantation Management and Practices

Company Information (If different from Section II)	
3.1. Name	
3.2. Address	
Phone	
FAX	
3.3. Name/position of contact person	
E-mail	
3.4. Name of plantation	
3.5. Location	
3.6. Plantation Size (hectare)	

Additional information (if applicable)	
3.7. Success rate (%)	
3.8. Capacity of palm tree/hectare	
3.9. Duration from seedling to harvest	
3.10. Annual crop/ perennial crop	
3.11. Life span of perennial crop (years)	
3.12. Land-Use prior to current crop (at time of data collection)	(Please tick ✓)
- Forest land to cropland	□
- Grassland to cropland	□
- Cropland to cropland (same crop)	□
- Cropland to cropland (different crop, please specify)	□
- Peatland to cropland	□

(Please provide figures or information 3 years if available, otherwise approximate current figures are also acceptable)	
3.13.	Plantation yield as average metric tons of biomass resource material for bioenergy e.g. (fresh fruit bunches per hectare/per year or per month for oil palms)

	200_	
	200_	
	200_	
	General average	
3.14.	Weight of fronds/stems fell per hectare / per year	
	200_	
	200_	
	200_	
	General average	

3.15.	Consumables consumption / year				
	Consumable	200_	200_	200_	General average
	Water (litre)				
	Electricity (kWh)				
	Diesel (litre)				

Data Treatment to Estimate Electricity Consumption		
3.16.	Use of electric-powered equipment and systems	
	No. of sprinklers/hectare	
	Motor power of sprinkler, kW	

Data Treatment to Estimate Diesel/Fuel Consumption		
3.17	Transportation from plantation to feedstock processing/ mill	
	Distance, km	
	Truck capacity, ton	
	Actual load, ton	
	Empty return (yes/no)	
	No. of trips/day	

3.18.	Agrochemicals consumption / year				
	Consumable	200_	200_	200_	Average
	Fertiliser • ______________ • ______________ • ______________ • ______________				
	Pesticides • _______________ • _______________ • _______________ • _______________				
	Others • _______________ • _______________ • _______________				

3.19. Waste Use or Produce	
Biomass Waste • Weight of frond fell/hectare/year • Agriculture waste/hectare/year • Wastewater/year	
Hazardous waste produce/year	

V. Processing of Feedstock Material

Milling Stage/ Processing Stage (to convert biomass stock to first bioenergy feedstock

Company Information (If different from preceding sections)	
4.1. Name	
4.2. Address	
Phone	
FAX	
4.3. Name/position of contact person	
E-mail	

4.4. Production Data

Please provide information for three years if available, otherwise approximate current values are acceptable

Production volume (metric tons/year)				
Types of Products	200_	200_	200_	Average
E.g. CPO				
E.g. Palm kernel				

4.5. Consumption Data

Raw material consumption (metric tons/year)				
Types of Raw Materials	200_	200_	200_	Average
E.g. Fresh fruit bunch				

Utilities & fuel consumption on yearly basis				
Utilities	200_	200_	200_	Average

Electricity (kWh/year) • Grid • Self generated				
Water (m^3/year) • Piped water • Recycling				
Fuel (litre/year) • Medium Fuel Oil • Diesel				

4.6. Environmental Data

Air Emission

Flue gas volume/production day (m^3/day) =

(Please sum up all volumes if more than one stack):

Parameters	Concentration
• Carbon dioxide CO_2 • Carbon monoxide CO • Methane CH_4 • Nitrogen monoxide N_2O • Nitrogen dioxide NO_2 Compliance to local regulations (state name of regulations)____________________________ ____	

4.7. Waste Generation

Types of Waste	
Waste produce (metric ton/year)	
Wastewater treatment sludge - organic (metric ton/year) - inorganic (*Please state type of mineral sludges e.g. hydroxide or carbonate etc.*(metric ton/year)	
Fiber (metric ton/year)	
Shell (metric ton/year)	
Boiler ash (metric ton/year)	
Hazardous waste:	

4.8. Wastewater Discharge

Wastewater discharge after treatment (m^3/year) =

Parameter	Concentration (mg/l)
• BOD • COD	

• • • • • • • • • • • •	

V. Refinery Stage (if applicable)

Company Information (If different from preceding sections)	
5.1. Name	
5.2. Address	
Phone	
FAX	
5.3. Name/position of contact person	
E-mail	

5.4. Production Data

Production volume (metric tons/year)				
Types of Products	200_	200_	200_	Average

5.5. Consumption Data

Raw material consumption (metric tons/year)				
Types of Raw Materials	200_	200_	200_	Average

5.6. Utilities & fuel consumption on yearly basis				
Utilities	200_	200_	200_	Average
Electricity (kWh/year) • Grid				

• Self-generated				
Water (m^3/year) • Piped water • Other source____________				
Fuel • Medium Fuel Oil (litre/year) • Diesel (litre/year) • Natural Gas (vol/year) • Coal (ton/year • Biomass (ton/year)				

5.7. Environmental Data
Air Emission
Flue gas volume/production day (m^3/day) =
(Please sum up all volumes if more than one stack) :

Parameters	Concentration
• Carbon dioxide CO_2 • Carbon monoxide CO	
• Methane CH_4 • Nitrogen monoxide N_2O • Nitrogen dioxide NO_2 • • •	
Compliance to local regulations?	☐Yes ☐No
Name of regulation___________________	

5.8. Waste Generation

Types of Waste	
Waste produce (ton/year)	
Wastewater treatment sludge - organic (metric ton/year) - inorganic (*Please state type of mineral sludges e.g. hydroxide or carbonate etc.*(metric ton/year)	
Hazardous waste (ton/year)	

5.9. Wastewater Discharge

Wastewater discharge after treatment (m^3/year) =

Parameter	Concentration (mg/l)
• BOD • COD • • • • • • • •	

VI Transformation to Biofuel

Company Information	
6.1. Name	
6.2. Address	
Phone	
FAX	
6.3. Name/position of contact person	
E-mail	

6.4. Production Data

Production volume (metric tons/year)				
Types of Products	200_	200_	200_	Average
Biodiesel				

6.5. Consumption Data

Raw material consumption (metric tons/year)				
Raw Materials	200_	200_	200_	Average

6.6. Utilities & fuel consumption on yearly basis				
Utilities	200_	200_	200_	Average
Electricity (kWh/year) • Grid • Self-generated				
Water (m^3/year) • JBA • Other source				
Fuel • Medium Fuel Oil (litre/year) • Diesel (litre/year) • Natural gas (vol/year) • Coal (ton/year) • Biomass (ton/year)				

6.7. Environmental Data

Air Emission

Flue gas volume/production day (m^3/day) =

(Please sum up all volumes if more than one stack):

Parameters	Concentration
• Carbon dioxide CO_2 • Carbon monoxide CO • Methane CH_4 • Nitrogen monoxide N_2O • Nitrogen dioxide NO_2 • • • •	
Compliance to local regulations? ______________________________	☐Yes ☐No

6.8. Waste Generation

Types of Waste	
Waste produce (metric ton/year)	

Wastewater treatment sludge - organic (metric ton/year) - inorganic (*Please state type of mineral sludges e.g. hydroxide or carbonate etc.*(metric ton/year)	
Hazardous waste	

6.9. Wastewater Discharge

Wastewater discharge after treatment (m^3/year) =

Parameter	Concentration (mg/l)
• BOD • COD • • • • • • • • • •	

<u>QUESTIONNAIRE FOR TRADERS/PROCESSORS</u>

Appendix［2］

Appendix［2-1］PILOT STUDY - ECONOMICS

I . GENERAL INFORMATION

1.1. Name (optional) (First Name)		
(Middle Name)		
(Last Name)		
Age		
Gender	☐Male	☐Female
Educational Attainment	☐Elementary ☐College ☐High school ☐Vocational ☐Post Graduate	
Civil Status	☐Married ☐Widowed ☐Single ☐Separated	
1.2. Main Source of Income		
Monthly Income		
Other Sources		
Monthly Income		

1.3. Years in Farming:________ Source of capital_______ Initial capital(P)_________

1.4. Membership in Organization

Name of Organization	Position	Number of Years	Involvement in Organization

1.5 Are you involved in community activities?	☐Yes	☐No
1.5a. If yes, what activities?		

1.6. Household information

Relationship with Respondent	Gender	Age	Civil Status	Educational Attainment	Occupation	Monthly Income

II. Plant/Firm Inputs

2.1. Plant size		2.2. Acquisition Cost	
2.3. Total number of employees		2.4. Plant capacity	
2.5. Raw material(s) processed		2.6 Products produced	

2.7. Initial Investment Cost

Inventory of Fixed Assets	Quantity	Year acquired	Life span	Acquisition cost
Land				
Building				
Tools and Equipment				

Work Animals				
Others				
Sub-total				

2.8. Operating Cost			
Cost Item	**Quantity**	**Salary/month**	**Total Cost**
Permanent Labor			
Manager			
Supervisor			
Bookkeeper/Accountant			
Secretary			
Others			
Hired/Contract Labor ***(in man days)***	**Mandays/month**	**Wage/day**	**Total Cost**
Purchase of raw material			
Processing			
Sub-total			
Material Cost	**Quantity/month**	**Cost/Unit**	**Total Cost**
Raw materials			
Other inputs (Specify)			
Marketing Cost			
Hauling/transportation			
Fees and others			
Sub-total			
Taxes paid			
Other costs			
TOTAL			

2.9 Procurement of raw materials				
Sources/Location	Product kind/form	Qty. / proc.	Frequency/month	Price/unit

IV. Disposal				
MODE OF DISPOSAL	QUANTITY	PRICE	BUYER	MODE OF DISPOSAL
	Per cycle	Lean Months	Peak Months	
Form of processed				
a.				
b.				
Other sales such as by-products				
Given Away				
Outlets Name/Location	Type of outlet/buyer	Quantity (unit)& type	Price/unit	Frequency /vol. of sale
TOTAL				

QUESTIONNAIRE FOR PRODUCERS

Appendix ［2-2］ PILOT STUDY - COCONUT

I . GENERAL INFORMATION

1.1. Name (optional) (First Name)		
(Middle Name)		
(Last Name)		
Age		
Gender	☐Male	☐Female
Educational Attainment	☐Elementary ☐College ☐High school ☐Vocational ☐Post Graduate	
Civil Status	☐Married ☐Widowed ☐Single ☐Separated	
1.2. Main Source of Income		
Monthly Income		
Other Sources		
Monthly Income		

1.3. Years in Farming:________ Source of capital________ Initial capital(P)__________

1.4. Membership in Organization

Name of Organization	Position	Number of Years	Involvement in Organization

1.5 Are you involved in community activities?	☐Yes	☐No
1.5a. If yes, what activities?		

1.6. Household information

Relationship with Respondent	Gender	Age	Civil Status	Educational Attainment	Occupation	Monthly Income

1.7. Did you encounter problems in planting coconut? ☐Yes ☐No

Problem	Check if Yes (✓)	Solution Adopted
Planting Materials		
High rate of mortality	☐	
High cost of planting materials	☐	
Non-availability of planting materials	☐	
Technology		
Difficult to adopt	☐	
Financial		

Lack of financial support Higher interest rate on loans	☐ ☐	
Market Lesser access to market	 ☐	
Pest and Diseases		
Harvest/Post-Harvest		
Processing		

II. Farm Inputs

2.1. When did you first plant coconut? ____________________ No. of pieces planted: ____________ Source:_________
2.2. After your 1st purchase did you buy more? How many? _________________ Comment on Price ______________
2.3. When was the last purchase?_____________ Qty_____________ Amount paid: _______________
2.3.1. If price is lower, how many would you buy?
2.4. Farm size:________________________ 2.4.1. Acquisition Cost: ____________________ 2.4.2. Total number of palms:____________ 2.4.3. Number of bearing palms: ______________ System of planting: ☐Monocrop ☐Backyard planting ☐Intercrop with other crops (specify)______________________ ☐Intercrop with coconut (specify number of macapuno relative to coconut)_______

2.5. Investment Cost			
Cost Item	**Quantity**	**Price/Unit**	**Total Cost**
Labor			
Land preparation (man day)			
Planting (man day)			
Fertilization (man day)			
Weeding (man day)			
Material Cost			
Seedlings or any planting material			
Fertilizer (bag)			
Pesticides (bag)			
Other chemicals			
Other Establishment Costs			
Ex. Fencing, licensing etc.			

Sub-total			

Inventory of Fixed Assets	Quantity	Year acquired	Life span	Acquisition cost
Land				
Building				
Tools and Equipment				
Work Animals				
Others				
Sub-total				

2.6. Operating Cost			
Cost Item	Quantity/month	Cost/Unit	Total Cost
Hired Labor *(in man days)*			
Farm overseer (man day)			
Grass cutting (man day)			
Watering (man day)			
Ringweeding			
Fertilization			
Deleafing			
Pesticide spraying			
Harvesting			
Collecting/piling			
Sub-total			
Material Cost	Quantity/month	Cost/Unit	Total Cost
Water (liters)			
Fertilizer (bag)			
Pesticides (bag)			
Other inputs (Specify)			
Marketing Cost			
Sub-total			
TOTAL			

Ⅲ. Production

Area planted by parcel	Type		Number of trees		Average yield/ palm/ harvest		Number of harvests/yr		Total produce / year	

3.1. Months of low yield ___________________ 3.1.1 harvest/mo______________

3.2. Months of high yield___________________ 3.2.1 harvest/mo______________

3.3. Contribution of produce to household income (%) ___________________

Ⅳ. Disposal

MODE OF DISPOSAL	QUANTITY	PRICE		BUYER
	Per harvest	Lean Months	Peak Months	
Sold as fresh				
Sold as mature nuts				
Sold as copra				
Planting material				
Payment in kind				
Home Consumption				
Given Away				
Used as planting materials				
Total				

Ⅴ. SOCIO –ECONOMIC CONDITION

5.1. Please check if the following items are available in the household	
a. Residential lot	☐Owned ☐Rented ☐Others, pls pecify__________
b. House ownership	☐Owned ☐Rented ☐Others, pls pecify__________
c. Housing materials	☐Concrete ☐Wood ☐Wood and cement ☐Nipa ☐Others, pls specify______________
d. Source of water	☐Artesian well ☐Pump ☐Others, specify________
e. Toilet Facility	☐Flush ☐Manual flush ☐Others, specify ________
f. Lighting Facilities	☐Electric ☐Lamp/gas ☐Others, specify ________
g. Cooking facilities	☐Wood ☐Kerosene ☐Charcoal ☐LPG ☐Electricity ☐Others, specify________
5.2. Household items bought because of biomass planting? __________________________ __________________________ __________________________ __________________________ __________________________ __________________________	
5.3. How would you describe your level of living before planting biomass? ____ ____	
5.4. How would you describe your level of living after planting biomass? ☐Better than before Reason: ____ ____ ☐Same as before Reason: ____ ____ ☐Worse than before Reason: ____ ____	
5.5. What is/are your aspiration(s) for your family? ____ ____	

5.6. Do you think the planting of biomass will help you with the attainment of your aspirations?
☐Yes ☐No

If yes, in what way? ____________________
If no, why not? ____________________

VI. CHANGES IN THE ENVIRONMENTAL CONDITIONS/ELEMENTS

Please check based on your perception and state reasons for the choice/response

5.7. Are there changes in the following properties of the soil in your farm after you planted biomass?

BA = Before Adoption *AA = After Adoption*

Soil properties		Rating *(please check)* (5-very dark, 4-dark, 3-slightly dark, 2-light, 1- very light)					Reason for the Rating
		1	2	3	4	5	
1.1. Color	BA						
	AA						
Soil properties		Rating *(please check)* (5-very fast infiltration, 4-fast infiltration, 3-slightly fast, 2-slow, 1-very slow)					Reason for the Rating
		1	2	3	4	5	
1.2. Porosity or ease of infiltration of water	BA						
	AA						
Soil properties		Rating *(please check)* (5-very abundant,4-more abundant, 3-abundant,2-less, 1-least)					Reason for the Rating
		1	2	3	4	5	
1.3. Abundance of humus or organic matter	BA						
	AA						
Soil properties		Rating *(please check)* (5-least acidic,4-less acidic, 3-acidic,2-more acidic,1-very acidic)					Reason for the Rating
		1	2	3	4	5	
1.4. Acidity	BA						
	AA						
Soil properties		Rating *(please check)* (5-very low,4-low,3-high, 2-moer high,1-very high)					Reason for the Rating
		1	2	3	4	5	
1.5. Occurrence and extent of soil erosion	BA						
	AA						
Soil properties		Rating *(please check)* (5-very deep,4-moredeep,3-deep, 2-shallow,1-very shallow)					Reason for the Rating
		1	2	3	4	5	
1.6. Depth of litter/gradient of	BA						
	AA						

decomposition							
Soil properties		Rating *(please check)* (5-very fertile, 4-more fertile, 3-fertile, 2-less, 1-least)					Reason for the Rating
		1	2	3	4	5	
1.7.General fertility	BA						
	AA						

5.8. Are there changes in water properties in nearby streams or creeks after the adoption of biomass technology?

BA = Before Adoption *AA = After Adoption*

Water properties		Rating *(please check)* (5-very clear,4-more clear,3-clear, 2-dark,1-very dark)					Reason for the Rating
		1	2	3	4	5	
1.1. Color of Water	BA						
	AA						
Water properties		Rating *(please check)* (5-very abundant,4-more abundant, 3-abundant,2-less abundant, 1-least abundant)					Reason for the Rating
		1	2	3	4	5	
1.2. Quantity	BA						
	AA						
Water properties		Rating *(please check)* (5-very abundant,4-more abundant, 3-abundant,2-less abundant, 1-least abundant)					Reason for the Rating
		1	2	3	4	5	
1.3. Abundance of organic matter	BA						
	AA						
Water properties		Rating *(please check)* (5-least acidic,4-more less acidic, 3-acidic,2-more acidic, 1-very acidic)					Reason for the Rating
		1	2	3	4	5	
1.4. Acidity	BA						
	AA						

5.9. Changes in abundance and variety of plants and animals

BA = Before Adoption *AA = After Adoption*

Properties		Rating *(please check)* (5-very many, 4-many, 3-just enough, 2-few, 1-very few)					Reason for the Rating
		1	2	3	4	5	
1.1. Number of animals							
1.1.a Beneficial *(e.g. butterflies, bees, dragonflies, etc.)*	BA						
	AA						

1.1.b Harmful *(e.g. snakes, rodents, mosquitoes)*	BA						
	AA						
Properties		Rating *(please check)* (5-very many, 4-many, 3-just enough, 2-few, 1-very few)					Reason for the Rating
		1	2	3	4	5	
1.2. Number of plants							
1.2.a Vegetation	BA						
	AA						
1.2.b Undergrowth	BA						
	AA						

5.10. Other changes in the environment

Properties	Before adoption ✓	Reason	After adoption	Reason
Presence of chemicals not properly disposed	( )		(✓)	
Presence of waste not properly disposed				
Littered plastics and other non-biodegradable materials like plastics				
Presence of impermeable structures *(e.g. pathways, buildings, cemented structures)*				

QUESTIONNAIRE

Appendix［3］ PILOT STUDY - SOCIAL

I . PERSONAL AND GENERAL INFORMATION

1.1. Name of the Respondent (individual/ firm)	
1.2. Address	
Phone	
FAX	
E-mail	
1.3. Age /Date of incorporation	
1.4. Qualification (Self/ Head)	
1.5. Occupation (Self/ Head)	
1.6. If individual, total number of family members Males ____________ Females __________ Children __________ Infants __________	
1.7. In case of individual, Income per month (in Rs) Personal __________ Family __________ Expenditure __________ Savings __________	
1.8. For Individual, how much do you spend your income (in percent) Food __________ Cloth __________ Housing __________ Education __________ Health __________ Other items(specify) ______________________________________	
1.9. In case of Firm, Type of Facility ____ No. of workers ________________________ Annual Turnover ________________________ Expenditure __________________________ Net Income _____________________________	
1.10. Location of Biofuel crops farm	
1.11. Location of Biodiesel production unit	

Ⅱ. CULTIVATION AND SEED COLLECTION STAGE

2.1. Are you a Farmer or Worker at Biofuel Crops Farm?	
2.1.1. If farmer, how did you hear about Jatropha/ Oil-Tree cultivation?	
2.2. Do you own biofuel crop farms?	☐Yes ☐No_______________
2.2.1. If yes, what is the type of crop Jatropha/ Pongamia/ others_________________	
2.3. Is your farm rainfed or irrigated?	
2.4. What are other input? (water/ fertilizers/ pesticides etc.)	
2.5. Is it on a waste land or cultivable land or both?	
2.6. What is the size of your farm?	Waste Land ___________cultivable land ___________

2.7. When did you start cultivation?	
2.8. Wherefrom do you obtain seedlings, seed and planting material? (tick where appropriate) ☐Own nurseries ☐Govt nurseries (district or regional authorities)-NGO nurseries ☐Community nurseries (owned by a group of people) ☐College nurseries ☐Individual farmers' nurseries ☐Others	
2.9. Are the seeds/seedlings sold/given free?	☐Yes ☐No
2.9.1. If No, prices range from______________ to ____________________________	
2.10. How many persons are involved in Jatropha Cultivation at your farm? Total______________ Your own family members______________ others (hired) ______	
2.10.1. If hired, how much do you pay them per day?	
2.11. If you have used all of your land for biofuel crops, what is the alternate source of income during gestation period of 2-4 years? ______________________________	
2.12. If diverted cultivable land, how do you meet your daily needs of food grain, vegetables, etc. that you were gaining form your farms earlier_______________	
2.13. What is the amount of Seed Collection per day?	
2.14. Where are the seeds consumed?	
2.15. How much do you pay/ are you paid for seed collection?	
2.16. If you are involved in oil extraction how much are you paid per day?	
2.17. How much is your income per day / month/ year from biofuel crop cultivation? Expenditure on wages_________ other Expenses________ Net earnings_______	
2.18. If you are a worker, what is your income from working in the farm for cultivation / seed collection Personal___________________ Family___________________	
2.19. How do you spend the increased income? Cloth__________ Housing_____________ Education_________ Health_________ Other items(specify)____	
2.20. Do you face any problem after starting cultivation of biofuel crops/ working in the farm? (Specify)__________________________________	
2.21. What measures do you suggest to tackle above problems	

Ⅲ. OIL EXTRACTION AND BIODIESEL PRODUCTION STAGE

3.1. Status of Company (Govt., Pvt., Partnership, etc.)	
3.2. Production Capacity (TPD)	Installed_______________ Actual_____________
3.3. Technology available for biodiesel conversion (indigenous/ imported)	
3.3.1. If imported, wherefrom?	
3.4. What is the electricity consumption of the biodiesel plant, MWh/year	
3.5. What is the fossil fuel consumption of the biodiesel plant, if any, tones/year? And what kind of fuel(s) (gas, coal, diesel, biodiesel, other:)?	
3.6. What is the mass of methanol consumed in the biodiesel plant, tones/year?	
3.7. Quality of Biodiesel produced (as per standards of)	
3.8. Quality of by-products produced (as per standards of)	
3.9. Raw Material Requirement per day__________ seed_________ oil____________	
3.10. Type of Raw Material required Jatropha__________ Pongamia______________ Others (specify share of each)____	
3.11. Source of Raw Material (oil /seeds) (Owned/ Contract Farming/other)___________________________	
3.11.1. If Owned / contract farming, areas under cultivation _______________________	
3.12. Cost incurred per hectare / ton on raw material, if owned ___________________	
3.13. Cost of Raw material per ton if purchased from market ______________________	
3.14. Raw material available is just enough/ insufficient/ over supplied______________	
3.15. No. of workers employed in Cultivation _______________wage per day________	
3.16. No. of workers employed for Seed Collection__________ wage per day ________	
3.17. No. of workers Employed in Oil Extraction_____________ wage per day _______	
3.18. No. of workers Employed in Biodiesel Production______ wage per day _______	
3.19. No. of workers Employed in Other Activities______ wage per day ___________	
3.20. List the output (quantity and name like biodiesel & main by-products) ____ ____	
3.21. Producing biodiesel for local market or exports____________________________	
3.21.1. If exports, to which country (ies)____	
3.22. If for local market, how do you reach consumers (self/ through distribution chain, specify details)____	

3.23. Net savings from per ton of products and by products ____ ____	
3.24. Existing support by the govt/ any other agency______________________	
3.25. If you feel some barriers, what are those?	
3.26. What solutions you suggest to remove these barriers?	
3.27. Any initiative for the farmers / workers / community as a part of your CSR? (Please name the activity and indicate expenses towards it and direct and indirect and indirect benefits achieved by you/ community). Some of the examples are as follows. Does your company/ activity - i) Help in promoting sustainable livelihoods and achieve self sufficiency in energy in the local region (how?)____________________ ii) Creates employment (how much?)____________________ iii) Promotes contract farming by marginal, small, medium and large farmers in the area ______________________________ iv) Initiates Ancillary Activities such as Vermicompost and Apiculture. Or Set up Tiny Industries such as Distillation, Drying, Soap making and Rope making. ______________________________ v) Creates additional income through Certified Emission Reductions (Carbon Credits). ______________________________ Any other (please specify) ______________________________	

IV. SURVEY OF CONSUMPTION STAGE

4.1. Does your facility use Biodiesel?	□Yes □No
4.2. Reasons for your facility using Biodiesel *(Check all that apply)* ☐Satisfy Mandate ☐Environment ☐Energy Policy ☐Safety Issues ☐Energy Bill ☐Agency Direction ☐Any other (please specify)____________________	
4.3. Types of Biodiesel being used. *(Check all that apply)* ☐B100 ☐B50 ☐B20 ☐B10 ☐B5 ☐Other (specify) __________	
4.4. Estimated Monthly Volume of each type. B100 _____ B50_____ B20 _____ B5 _____ Other _____ Total ________	
4.5. What applications are you using Biodiesel for? (vehicles/ generators/ others)	
4.6. Number of vehicles that use biodiesel.	
4.7. Where do you purchase your biodiesel from?	
4.8. How much cost do you pay for biodiesel? *(Per Litre)*	
4.9. Have you encountered problems from biodiesel usage? *(If yes, please explain)* ☐Yes ☐No ____	
4.10. Do you have a biodiesel success story you would like to share? (*If yes, please explain)* ☐Yes ☐No ____	

V. OTHER INFORMATION

5.1. Do you know about merits and demerits of biodiesel over petro-diesel? ☐Yes ☐No	
5.1.1. If yes, what are those?	
5.2. Is biodiesel available locally/ nearby easily?	
5.3. Price of biofuel that you are paying____	
5.4. Is government providing any help in Biodiesel promotion? ☐Yes ☐No	
5.4.1. If yes, what are those?	
5.4.2. If not, what do you expect?	
5.5. Do you feel there is any change in Eco restoration and land degradation(preventing) due to use of biofuel crops cultivation______________________________________	
5.6. Is any extra effort necessary for biofuel crop in comparison to other crop?	
5.7. Do you see any change in rural electrification and energy security due to use of biofuel in your areas____	
5..8. Any additional information that you may want to provide here, ____	