EXECUTIVE SUMMARY

1. BACKGROUND

The use of fossil fuels for transport and other economic activities is constrained due to economic and environmental concerns in the East Asian region. In addition, increased energy demand in developing economies of this region may result in problems of energy security. If energy demand in East Asia is not met urgently, it may severely affect the development of the region. These and similar other factors have forced policy makers in developing countries to use alternative sources of energy such as non-conventional or renewable sources. Among various sources of renewable energy, the development of bioenergy, in the form of biodiesel, bioethanol, biopower, etc., has emerged as an important option. Different forms of bioenergy are being produced and used in various countries with predominance of bioethanol and biodiesel. For example, in Brazil, USA, Sweden, Australia, Thailand, and India bioethanol is blended with gasoline, in the range of 5-20%, and used as transport fuel.

If managed properly, development and use of bioenergy may accrue several benefits in East Asia both on environmental and socio-economic fronts. A judicious selection of bioenergy would help in reducing greenhouse gases (GHGs) emissions. Further, biomass is mostly produced by local farmers, and increased demand for it may improve their employment and income. Increased income may contribute to the improvement of their quality of life. On the other hand, accelerated use of bioenergy could have several negative impacts and aggravate problems of shortage of water, food, fodder, land, etc. in the region. Some biomass resources are utilised as food, fodder or for other domestic activities in developing economies. Increased demand of biomass for energy generation may cause an imbalance and prices of food crops such as sugar, corn, wheat, etc. may rise, affecting economically weaker sections of the society in the East Asian region.

This project investigates various aspects of “Sustainable Biomass Utilisation in East Asia.” An elaborate research was conducted by a multi-disciplinary working group (WG), consisting of the Economic Research Institute for ASEAN and East Asia (ERIA) experts in energy, environment, social-sciences and economics, within the East Asian region. The WG highlighted the crucial issues and suggested some necessary steps for achieving a sustainable development of biomass utilisation in the region.

2. CONCEPT

The UN World Commission on Environment and Development (WCED) report “Our Common Future”, published in 1987, defines sustainable development as "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 minimise the problems cited above.

In view of the above, the WG, through elaborate research and group discussions over six months, produced this report titled "Sustainable Biomass Utilisation Vision in East Asia", which is essentially based upon the above criteria.

2.1. Economic aspects

Beneficial biomass utilisation in East Asia is expected to generate extra income, through value addition, for local stakeholders including farmers, labourers, energy producers and local/national governments. It may contribute to economic gains for East Asian countries, by reducing imports of fossil fuels, and less dependence on imported fuels may also enhance energy security in the region. However, for maximising economic benefits, energy production potential of each biomass resource should be evaluated and appropriate technologies should be used for energy production. To ascertain this, some case studies have been conducted in the region, which performed economic impact assessment of bioenergy, in terms of value addition at each stage, such as job creation, tax revenue generation, and foreign trade.

2.2. Social aspects

Development of biofuels may have several socio-economic implications in East Asian countries. Positive social impacts of bioenergy are increased employment and income in rural areas, and hence, reduction in income disparity among rural riches and poor and in urban and rural areas; higher income may contribute to better health prospects for all, particularly, for women and children; better life style, etc. Negative impacts could be increased pressure on natural resources such as water, land and forests. Also, biofuel crops may compete with other food and fodder crops and reduce their supplies resulting in higher food prices. The case studies on social issues were aimed at preliminary estimation of disparity of income in the region and its reduction due to bioenergy development. The case studies were based upon relevant indices developed by international organisations but further investigations are needed for reliable and accurate estimations of social impacts.

2.3. Environmental aspects

Along with the interest to utilise biomass for energy production, there exists a myriad of interconnected environmental factors that has to be taken into account. The merits of any biomass energy production should be assessed along with some crucial sustainable indicators and environmental concerns including: deforestation / land use, water management, fertilizers and pesticides, carbon footprint and energy inputs. If large amounts of energy and resources are consumed during the production of biomass and biofuels, the entire system's energy balance will tend to result in energy losses instead of gains. The same logic holds for GHGs; low or zero carbon biofules can only be achievable with proper conditions in place (elaborated in Chapter 4). The lifecycle carbon-footprint and energy equilibrium of such a system has to be considered carefully.

3. RESULTS

3.1. Economic aspects

Biomass utilisation for energy benefits local and regional economic development through job creation in rural areas on continued basis, foreign exchange saving from reduced oil imports, development of alternative markets for biomass products, and generation of tax revenue for governments.

Based on review of literature, the case studies on economic aspects of bioenergy can be classified into three types, namely, microlevel studies (to calculate the economics of bioenergy from the perspective of an individual economic agent); sector-wide studies (to assess the aggregate response of the entire sector to a policy usually taken from the policymaker's perspective); and input-output (I-O) model studies (to describe the complete economic impacts of industrial activity applying a general equilibrium analysis). While microlevel studies were found to dominate in developing countries in Asia, I-O studies are more common in developed countries such as Japan, the United States and the EU. Most of the studies that were taken into consideration enumerated the positive effects of biomass energy policies to local income, taxes, and rural employment. There is a need for developing I-O models for developing countries, which would be able to assess such effects in Asian economies.

The review assessed the role of biomass in developing economies in East Asia by evaluating the past, current, and future trends of biomass utilisation. Economic impact assessment for East Asian countries is based on GDP, employment, energy security, and foreign exchange savings. Employment generation was found to be a common benefit from biomass-based industries especially in the services sector. In terms of the macroeconomic indicator, i.e. GDP, a generally positive trend with increase in bioenergy share was observed. Net fossil fuel importing economies not only could save fuel dollars but also would be able to diversify their energy resources giving them long term energy security.

Some estimations of benefits from biomass production and its conversion into energy were made through a case study of the Philippines, which assessed economic impacts at a micro level. The study assessed the economic impacts in terms of value addition, job creation, tax revenue generation, and foreign exchange savings and earnings. The overall economic impact of the biomass-based industries was found to be significant not only at the provincial or regional level within the country but also to the national economy as a whole. The potential economic benefits of biomass energy are extensive. This study has revealed a generally positive trend in the macroeconomic indicator (GDP) with increase of biomass energy share. In addition, a number of employment opportunities can be achieved from the industry.

3.2. Social aspects

East Asian country governments are giving lot of impetus for the promotion of bioenergy and biofuels. In most of the countries a blending rate for biofuels has been proposed in the range of 5-10% in the short term with a long term target of 20%. As the demand for biofuels increases, production of biomass has to be increased, proportionately. Large scale cultivation of biofuel crops such as Jatropha, Coconut, Oil Palm, Sugarcane, etc. in East Asian countries is expected to generate millions of jobs in the farm sector and rural areas. With the help of a case study of India, it is revealed that to achieve 20% blending targets for biodiesel, Indian government hopes to increase Jatropha plantation up to 11.2 million hectares by 2011-12, with a job creation potential of about 311 man-days per hectare per year. Similarly, in case of ethanol, blending targets of 5-20%, by increasing sugarcane production, has a potential of creating jobs of 183 man-days per hectare per year. In addition, employment opportunities will be created in other stages of biofuel development chain.

Marginal income increase due to employment in bioenergy programmes showed positive impact on other parameters of social development and overall improvement in living standards of people in the region. Among the negative impacts of bioenergy, "food versus fuel debate" may be the most crucial issue for East Asian Countries. For long-term sustainability of biofuel programmes and to reduce their negative impacts, use of waste lands for growing biomass, use of agro-residue for bioenergy, use of non-edible oil for biodiesel and, depending upon the fluctuation in domestic sugar demand, use of both molasses and sugarcane juice for ethanol production could be the right strategies.

3.3. Environmental aspects

Along with the decreased use of fossil fuels, biomass is expected to contribute to mitigating climate change by reducing GHG emissions. However, this environmental advantage can be realized only if sustainable practices are in place. The most important step is to prevent the clearance of large tropical forests for the sake of growing biomass. Also it is necessary to avoid the overdose of artificial fertilizers that will result in nitrous oxide emissions, another greenhouse gas. It should be ensured that the harvesting rates of the biomass resources are not higher than the growing capacity of the agricultural land producing it. Sustainable agricultural land management will help to promote the carbon neutral (or in some cases carbon negative) effects of bioenergy.

The WG asserts a conservative approach to biomass utilisation for energy production. A useful measurement is the carbon footprint of the system, where the entire biomass-to-bioenergy production chain should be considered, including any additional energy and resources spent to grow, produce, and in some cases, transport the biomass feedstock by rail or roads.

By analysing the carbon footprint or by taking into consideration the entire life cycle of biofuel and assessing the GHG emissions from "field to fuel", a more accurate account of GHG emissions i.e. net reduction or increase, may be revealed.

3.4. Sustainability Indicators

The current impetus in the utilisation of biomass for materials and energy has generated a serious debate vis-à-vis its impact on food security. Also, from a life cycle perspective, the advantages of biomass utilisation for climate change mitigation are not as clear as were thought earlier. Hence, it is imperative to assess the sustainability of biomass utilisation. To this end, indicators addressing ecological, economic and social sustainability need to be developed. A suite of such indicators has been proposed as an attempt to quantify the ecological viability, social desirability and economic feasibility of biomass systems. Ecological indicators include thermodynamic metrics based on mass and energy balances and environmental metrics comprising carbon footprint, eutrophication, land use and biodiversity. Economic indicators incorporate income generation and energy security. The lack of quantifiable indicators for social sustainability was evident pointing to a need for further research in this important area.

4. POLICY RECOMMENDATIONS

Biomass production and utilisation for energy involve complex issues that may have significant implications on the economies within the East Asia region.

Sustainable utilisation of biomass should consider economic, environmental and social aspects. Based on the current findings of the WG, and the accepted benefit of biomass as a source of renewable energy that will reduce the rate of depletion of fossil fuels, following recommendations have been proposed for the 'Sustainable Biomass Utilisation Vision in East Asia.'

(1) Addressing Macro and Micro Levels Needs to Reap Maximum Economic Benefits

The economic impact of biomass utilisation should be considered from both macro-level and micro-level perspectives. This takes into account the economic benefit at national level, and its financial sustainability within the local economy. Regulations and subsidies are only short-term advantages, and therefore, the policies that will distribute the economic benefits to each stakeholder along the value-added chain of biomass energy, and also encourage growth of its supporting industries are favourable approaches.

(2) Enhancing Positive and Mitigating Negative Environmental Impacts

Agriculture activities are dominant contributors to the environmental impacts of biomass utilisation. Policies and strategies should be framed to enhance the positive impacts and minimise the negative impacts. The entire life cycle of the process should be considered to identify environmental hot spots or activities that result in the most extensive damage from a particular impact. The action plan to minimise negative impact should be prioritised according to the extent of damage of the hot spot on the environment.

(3) Realising Direct and Indirect Societal Benefits or Returns

Societal impacts include direct monetary benefits as in job creation and indirect monetary benefits in the form of better health and increased literacy and gender equality, etc. Societal benefits vary with their role in the value chain and this variation should be considered in policy framing. Policies must be developed to ensure that food security is not threatened at the expense of energy security and should be designed in such a way that they benefit all strata of the society.

(4) Developing Sustainability Indicators to Enhance the Decision Making Process

Sustainable development indicators should address ecological, economic and social sustainability. Currently, there is no single indicator to integrate all three aspects and a suitable indicator for the same is yet to be developed. However, every indicator need not to be applied in the decision making process. Harmonisation of indicators at the regional level, development of indicators that can integrate all three aspects and indicators that can address complex issues such as energy security should be actively pursued.

(5) Using Appropriate Tools to Generate Quantifiable and Verifiable Life Cycle Information

Appropriate evaluation tools or techniques will enable the generation of quantifiable information and data for use by the indicators. Life Cycle Assessment (LCA) is an established tool that can provide life cycle footprints for critical environmental impact categories. The use of LCA will also ensure those negative impacts are not passed from one environmental compartment to another, from one time frame to another, or from one region to another.

(6) Considering Country-Specific Needs and Available Biomass Resources

Depending on the country's experience and needs, the driving force to propagate the biomass energy industry can be economic, environmental or social factors, or a combination of these factors. Careful assessment should be conducted to ensure that the decisions and actions are in accordance with the priorities of the country.

(7) Promoting Regional and International Cooperation

Within the East Asian region as well as at international level, each country should pay due attention to the policies and approaches that are adopted by other Countries. Collaboration between bioenergy producing and bioenergy consuming countries in East Asia, including technology exchange, capacity building and appropriate pricing, should be given priority for sustainable biomass utilisation.

CHAPTER 1

INTRODUCTION

1.1. Background

Biomass is defined as the organic matter formed due to natural or anthropogenic process and it includes trees, plants and all kinds of vegetation, several types of waste such as agro-waste, forest residues, industrial wastes, animal waste and municipal solid waste (MSW). Natural biomass is in fact formed due to storage of solar energy in various types of vegetation in the presence of atmospheric moisture and carbon-dioxide. Chemically, biomass is a mixture of carbon, hydrogen, oxygen and nitrogen and the ratio of these chemical species vary in different types of biomass. The biomass can always be grown in the form of vegetation and, due to human activities; various types of waste are always generated. Energy derived from biomass is defined as a renewable energy and it may offer several merits over conventional energy.

Biofuels offer several socio-economic and environmental benefits, particularly in countries importing a large quantity of fossil fuels. A major economic advantage is found in savings from foreign exchange used to import fossil fuels. Another merit of biofuels is the reduction of greenhouse gases (GHGs), as biomass is regarded as a carbon neutral material. Its value as a carbon neutral material is based on its ability to accumulate carbon dioxide from the atmosphere during its growth and release the same when burnt or decomposed, and thus, does not add to the net carbon balance in the atmosphere. The reality of the entire process is however, more complex. Any change in land use or large clearance of tropical forest to grow more biomass resources may end up in emitting more GHGs than the expected reduction. The appropriate conditions to avoid a biofuel system that emits more carbon than it can possibly sequester are discussed in Chapter 4.

Due to rising environmental concerns of conventional energy forms, the global energy scenario has to be changed and bioenergy could offer a sustainable alternative. When burned or decomposed, the chemical energy in biomass is released in the form of either heat or gas. Use of biofuels reduces the emissions of pollutants such as carbon monoxide, unburnt hydrocarbons, particulate matter, polycyclic aromatic hydrocarbons (PAH) and nitrated PAH. Another environmental benefit of biofuels is that it contains virtually no sulphur. Presently, only select countries are promoting use of biofuels but in couple of decades it is expected that almost 25% of global energy demand will be met by the biofuels (UN-Energy, 2007).

1.1.1. Biomass Production

East Asian countries are endowed with rich biomass resources. Figures 1.1, 1.2, 1.3., 1.4 and 1.5 show share of some Asian countries in the production of major crops used for biofuels. Globally, more than 95% of coconut oil and 90% of rice and palm oil are produced in East Asian countries. As far as production of sugarcane and cassava is concerned, East Asian region has the second largest share in the world. Despite this, the farmers in many countries within this region are struggling for their livelihood due to low income. This is responsible for income disparity among various countries in the region and also between rural and urban areas within a country.

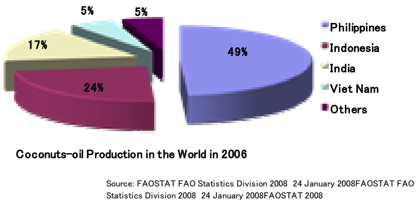


Fig. 1.1 Coconut oil production

Fig. 1.2 Cassava production

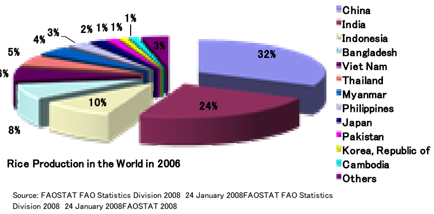


Fig. 1.3 Rice production

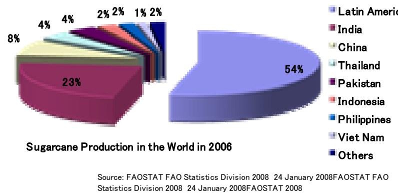


Fig.1.4 Sugarcane production

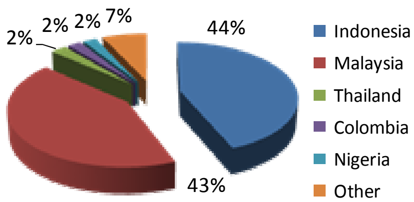


Fig. 1.5 Palm Oil Production

1.1.2. Biofuel Usage in East Asia

Many East Asian countries have extensive programmes on biomass energy and biodiesel and bioethanol are being developed as major transport biofuels in the region. In some countries, a few other forms of bioenergy such as "heat or electricity" by thermal gasification and "biogas" by anaerobic decomposition of biomass are also being promoted. Most biodiesels are fatty acid ethyl or methyl esters produced by trans-esterification of vegetable oils, both edible and non-edible, and can be used in vehicles up to 20% blend without any engine modifications. In most of the developed and even developing countries, edible oils have been used as raw material for producing biodiesel. But, in some East Asian countries like India, due to high cost and demand of edible oils, use of only non-edible oils have been proposed for biodiesel production so as to avoid competition with food.

Bioethanol is an oxygenate containing about 35% oxygen and produced by fermentation of three major types of biomass as raw material, namely, starch (such as grain, corn), sugar plants (such as sugar beet or sugarcane), tubers like cassava, and cellulose plants (such as trees, plants and agro-waste). Ethanol can be used upto 20% blending with petrol without any modification in vehicle engines. In the US and some European countries, cellulosic material has been used but in most East Asian countries, only molasses, a by-product of sugar industries, is used for the production of ethanol.

Table 1.1 shows the state of biofuel blending policy in some East Asian countries as compared with other major biofuel producing countries in the world. Each country employs different types of biomass for production of biofuels. In most of the East Asian countries, national policy on bio-fuels has been introduced in the last five years and present blending rates are in the range of 1% and 5%. Some countries have more challenging long-term targets of higher than 10%. To meet these targets, the demand for the biomass resources will increase in the region, substantially.

1.2. Impacts of bioenergy

Accelerated development of bioenergy in East Asian countries, would have several socio-economic and environmental impacts in the region. Biofuels have several positive impacts such as economic gains due to reduced import of fossil fuels, energy security due to diversification of energy types and employment generation due to cultivation of energy crops in rural areas. Higher employment rate will increase income in rural areas, which could result in better health prospects for all, and for women and children, in particular; better life style, etc. On the other hand, negative impacts of bioenergy could arise in price of food crops due to their increased demand for biofuels. Bioenergy crops may compete with other food and fodder crops and reduce their supplies resulting in higher food prices. Also, biomass cultivation on a large-scale may increase pressure on natural resources such as water, land and forests.

Some of these impacts are mentioned as follows.

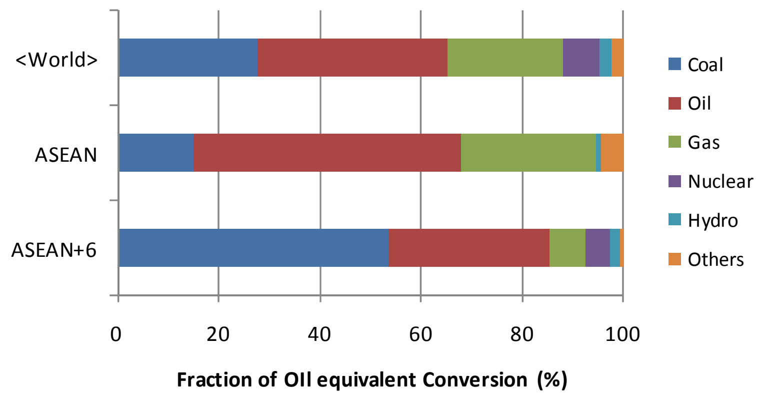
Table 1.1: Status of biofuel blending targets in some countries

Country	**Major Biofuel (Raw Material)**	**Blending Rates in 2007 (Future Targets) in %**	**Year of Biofuel Policy/ Act**
Australia	Ethanol (Sugarcane and Grains)	10	NA
Brazil	Ethanol (Sugarcane)	24	NA
China	Ethanol (Sugarcane) Biodiesel (used food oil and Jatropha)	5-20	2005
India	Ethanol (Molasses) Biodiesel (Jatropha and Pongemia oil)	5 10 (2008)	2003
Japan	Ethanol (Corn)	3	2003
Malaysia	Biodiesel (Palm Oil)	2-5	2005-06
Sweden	Ethanol (Corn)	20	NA
Thailand	Ethanol (Molasses) Biodiesel (Palm Oil)	Ethanol- 10 Biodiesel- 2 (2008) 5 (2010)	2005
The Philippines	Biodiesel (Coconut Oil)	1 2 (two years)	2006
USA	Ethanol (Corn)	10	NA

Source: TOI (2007); ERIA-WG Meeting (2008); NA- Not Available

1.2.1. Energy Security

Many East Asian countries are heavily dependent on fossil fuels such as coal, oil and natural gas and are net importers of these fuels. Figure 1.6 shows share of primary energy in East Asian countries in 2004, and indicates that more than 70% of the primary energy in these countries is produced using fossil fuels. Thus, promotion of bioenergy in East Asian region would diversify energy supply and could help in achieving energy security in the region.



Source : EDMC Energy- Economic Data Book 2007

Figure 1.6 Primary energy sources in some East Asian countries

1.2.2. GHG Emission Reduction

Since some Asian countries are showing a rapid economic growth, and therefore, their energy demand is increasing. A large growth in the consumption of fossil fuels is leading to a rapid increase of GHG emissions in this region. As shown in Figure 1.7, GHG emissions in Asia are higher than other regions. Though impact of post Kyoto Protocol measures are yet to be seen, GHG emission reduction targets are necessary and required to be met by most of the countries. If sustainable agricultural practices and proper land management are employed, biomass derived energy can be one of the major components for the reduction of GHG emissions.

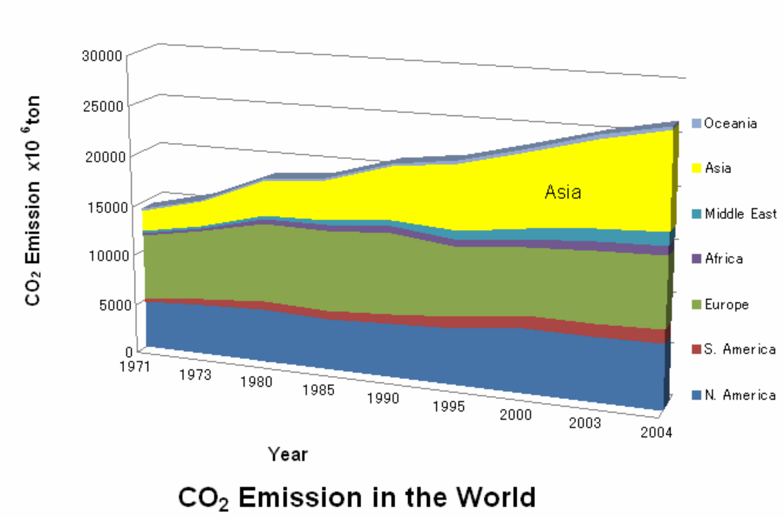


Fig. 1.7 GHG emission in the World

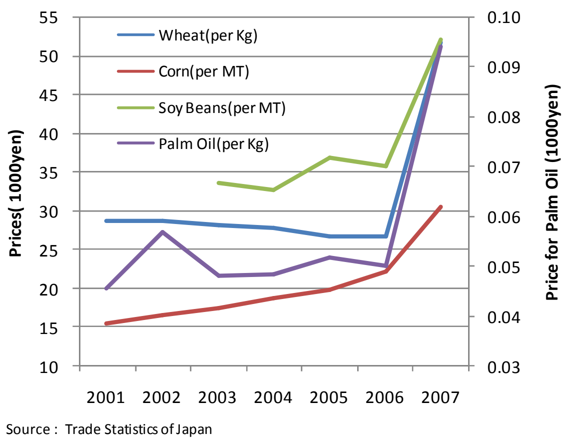


Figure 1.8 Recent annual prices of bioenergy related agriculture products

1.2.3. Rise in Food Price

Since the year 2006, the price of some food crops such as corn and wheat, which are used as feedstock for biofuels, have gone up as shown in Figure 1.8. One of the reasons of such sudden rise in price is high demand of these crops. Since these are basic food crops and are indispensable for human life, the higher price may inflict heavy damage on poor people relying, for meeting their nutrition needs, on these crops. Increasing demand of these crops for energy and food may result in continuous rise in their price, aggravating the situation further.

1.3. Objectives

As mentioned earlier, gap in energy demand and supply and high energy cost may adversely impact the development of the East Asian region. Global environmental concerns are recognized worldwide and we must contribute to resource conservation and environmental protection. Bioenergy is considered as carbon neutral and expected to contribute to GHG emission reduction, could be an alternate primary energy source. Since the production of biomass is mostly done by local farmers, increased demand for biomass must contribute to improvement in their employment and income levels, which, in turn, may enhance their quality of life. Development of bioenergy may also have positive impacts on local industries. On the other hand, some biomass resources are utilised as food and an increase in their demand for energy generation may result in reduced or expensive food supply. It might eventually affect household expenses, especially for poor people. With this background, biomass utilisation should be optimised keeping in view the conditions of people in East Asia.

The objective of this project is to study the “Sustainable Biomass Utilisation in East Asia.” Through an elaborate discussion among experts on environmental and socio-economic aspects, necessary measures are suggested to achieve the sustainable development of bioenergy in the region.

1.4. Method

The methodology used in this study is based upon the UN World Commission on Environment and Development (WCED) report titled as “Our Common Future”, which defines the sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." The Triple bottom lines, or "People, Planet, Profit", captures an expanded spectrum of values and criteria, for measuring organisational (and societal) success, are based upon economic, environmental and social aspects. Hence, for the sustainable utilisation of biomass resources, these aspects are necessary and must be considered to overcome the problems cited above.

The WG discussed the “Sustainable Biomass Utilisation Vision in East Asian Region” based upon the above criteria.

1.4.1. Economic aspects

Sustainable use of biomass for energy production is expected to generate economic gains for biomass growers (farmers) and, through value addition in the production chain, for local manufacturers. It must also contribute to decrease in imports of fossil fuels and provide energy security in the region. To maximise the beneficial effects, production potential of each biomass resource should be evaluated and then appropriate conversion technology should be applied. To ascertain this, some case studies to evaluate economic benefits of bioenergy are conducted in the region.

1.4.2. Environmental aspects

As the consumption of biofuels continues to increase, its environmental implications arising from increased demand for biomass, its cultivation and harvesting could be serious in the long-term. The environmental benefits of establishing small and large-scale biofuel industries in East Asia require thorough inspection. Unlike other renewable energies (solar, wind, sea waves, etc.), the supply of biomass resources is constrained by the availability of land, water and the climate conditions (e.g. temperature, precipitation). Energy and fertiliser inputs are also required in their growth and cultivation. The crops or biomass feedstock for biofuels are harvested using machinery that burns fossil diesel. In some cases, the total energy inputs required in the production of biomass and its conversion into energy may be more than the energy output of the final biofuel product. Hence, a life cycle approach should be applied to take into account the energy use and carbon footprint of the entire supply chain of the biofuel industry.

There would be ecological risks in the large scale development of agricultural systems for biomass production. Biofuels cannot be considered advantageous if their production results in environmental destruction, pollution and damage to society. Different biofuels vary enormously in how “green” they are, and promoting the right feedstock is crucial to ensure environmental sustainability. The environmental issues associated with biomass production and utilisation include deforestation, water scarcity and contamination, use of fertilisers and pesticides, carbon dioxide emissions and climate change, and finally, resource or energy consumption.

As long as biofuels are produced in a sustainable manner, they can bring many positive benefits to both the society and the environment. On the other hand, if not managed properly, ecosystem degradation may result in environmental and social damages. For example, deforestation due to land clearance (for biomass production) contributes to both climate change and loss of biodiversity, while the overuse of artificial fertilizers and pesticides leads to water contamination and emissions of nitrous oxide (another GHG).

1.4.3. Social aspects

Bioenergy production and utilisation are expected to improve quality of life of people in East Asia, especially of those living in rural areas and are lagging behind in the development process. Increased employment and income opportunities could make a difference in reduction in disparity of income in the region and also between rural and urban areas within a country. The WG experts discussed this issue and other social aspects of bioenergy and tried to find out the measurable social parameters based upon indices developed by international organisations. It was felt that further detailed work in this direction is needed to establish quantitative methods for calculating measurable social impact in the region.

CHAPTER 2

SUSTAINABILITY AND BIOMASS UTILISATION

2.1. Introduction

Biomass has been crucial for human subsistence as food, energy source as well as feedstock for various materials. One of the major issues around the current increasing use of biomass, especially for energy purposes, is the food versus fuel debate. If excessive land is utilised for producing biofuels feedstock, it is anticipated that there will be competition for land resulting in increased food prices thus negatively affecting the world's poorest. However, this argument is too simplistic as the evaluation of the effect of biomass for fuel on socio-economics is complicated by the fact that increased price of agricultural products will actually also benefit farmers who comprise a large portion of the world's poor. In fact, the anticipated positive effect on the rural economy and employment generation are two of the major areas for promotion of biofuels in many countries. Another major concern is the conversion of lands rich in biodiversity to monoculture plantations. On the other hand, the other argument is that biomass could be planted on degraded land which cannot be used for cultivation of food crops. This would help restore soil organic matter and nutrient content, stabilize erosion and improve moisture conditions (Johansson and Azar, 2007). In fact, it has even been argued that using surplus agricultural land for biofuel production is more advantageous for greenhouse gas reduction than afforestation (Schlamadinger and Marland, 1998). Thus, it is clear that the sustainability of biomass utilisation needs to be rigorously assessed.

Sustainable development has set the framework for policy making in various fields, including bioenergy, over the past two decades. It has been defined as development that "meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987). Sustainability of biomass implies that the biomass resources are utilised without degrading the environment or having negative socio-economic impacts.

The concept of sustainable development, though noble in intent, needs to be operationalised through development of indicators to quantify the ecological viability, social desirability and economic feasibility of systems (Figure 2.1). Indicators are quantified information which helps to explain how things are changing over time. They have three basic functions: simplification, quantification and communication. Indicators generally simplify in order to make complex phenomena quantifiable so that information can be communicated.

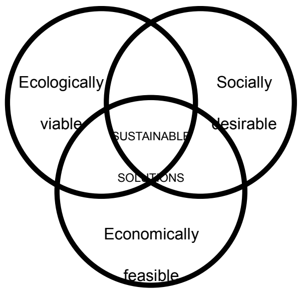


Figure 2.1: Sustainable solutions

Development of sustainability indicators that are relatively easy to characterize is a key to addressing the quest for sustainable development. Well-designed indicators can help assess progress towards policy objectives, as well as provide a basis for communicating with stakeholders.

While assessing biomass utilisation and developing sustainability indicators, one important thing to be considered is the life cycle or systems approach. This is important to ensure that the decisions made a one life cycle stage do not create adverse consequences at other stages, although these stages may seem disconnected from a narrowly focused objective. A very simple example is the comparison of only tail-pipe emissions from vehicles powered by fossil fuels and biofuels. From the perspective of greenhouse gas emissions, the biofuel-driven vehicles will obviously perform better as the CO_2 emissions from these, being assimilated into the biomass during its growth, are considered neutral. However, consideration of the biomass plantation stage shows significant greenhouse gas emissions from fertilizer production and use.

2.2. Classification of sustainability indicators

There is no single indicator which can embody all the issues of sustainability. Hence, a suite of indicators are needed.

2.2.1. Ecological sustainability indicators

(1) Thermodynamic metrics

Thermodynamic metrics are measures of intensity of use of materials and energy normalized to representative units such as per unit service or product. They are useful indicators of the efficiency of resource and energy utilisation; however, they do not directly indicate the environmental consequences thereof.

Material and energy intensity are easily quantifiable metrics based on the first law of thermodynamics – mass and energy balance. They are expressed in units of material used per unit (mass) of product or service (MIPS) and energy used (in joules) per unit (mass) of product or service. The disadvantage of such metrics is that they do not take into account the quality of the material or energy. For example, sand and gravel are lower quality materials as compared to refined metals. Similarly, coal and wood are lower quality energy sources (per joule) than electricity.

Nevertheless, these concepts have been widely used for assessing biomass systems. Net energy balance (NEB), which is the difference of energy output and energy input, is used as an indicator for comparing the energy efficiency of biofuels (Shapouri et al,, 2006; Nguyen et al., 2007; Nguyen et al., 2008; Prueksakorn and Gheewala, 2008). A negative NEB indicates that more energy is used to produce the biofuel than can actually be gained from the final product. Another commonly used measure for estimating the net energy value of fuels is the net energy ratio (NER) which is the ratio of the energy output to energy input. NER greater than 1 indicates a net energy gain whereas that less than one indicates a net energy loss.

The energy balance approach, as described above, is a relatively simple, but useful thermodynamic metric. It has, however, been criticized as it does not take into account the quality of energy. This issue can be critical in certain assessments of biomass systems where the end products have a high exergy and thus an exergy analysis may yield results that differ substantially from an energy analysis (Ulgiati, 2001; Dewulf et al., 2000; Hovelius and Hansson, 1999). The second law of thermodynamics dictates that due to entropy generation, the total energy available from the outputs (exergy of the outputs) is less than the total energy available from the inputs (exergy of the inputs) even though the total output energy is equal to the total input energy based on the first law of thermodynamics (Dewulf and Van Langenhove, 2006). Exergy is thus a very useful metric that has been successfully utilised for assessing the sustainability of biomass systems (Dewulf et al., 2006). From a life cycle perspective, the cumulative exergy consumption (CExC) is used as the metric (Dewulf et al., 2007).

(2) Environmental metrics

Environmental metrics quantify the environmental loadings or changes unlike thermodynamic metrics which are mainly focused on resource use. Environmental metrics of significance for biomass systems are mainly climate change, acidification, nutrient enrichment and toxicity. These metrics are captured in a life cycle assessment which is a tool for environmental assessment of products and services throughout the entire period of their lives from cradle to grave.

Climate change, which may lead to a broad range of impacts on ecosystems and our society, is calculated as global warming potential (GWP) which is an expression of the time integrated radiative effects of an atmospheric pollutant. It is characterized based on the extent to which the pollutants (GHGs) enhance the radiative forcing in the atmosphere, i.e. their capacity to absorb infrared radiation and thereby heat the atmosphere. There are several GHGs contributing to climate change, the major ones being carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and chlorofluorocarbons (CFCs). The total effect of all the GHGs gases is expressed in terms of CO_2 equivalents over a specific time period (usually 100 years). Biomass systems play in important role in trapping CO_2 during photosynthesis as well as carbon storage in the soil. On the other hand, GHGs can also be released from land use changes as well as nitrogen fertilizer applications. The total GWP over the entire life cycle of the system is used for comparison of biomass systems and is referred to also as the "carbon footprint".

Nutrient enrichment, leading to eutrophication, is another important metric for assessing the environmental sustainability of biomass systems. Excessively high levels of nutrients, usually from the application of fertilizers during biomass growth, can lead to shifts in species composition and increased biological productivity for example algal blooms (Baumann and Tillmann, 2004). Nitrogen and phosphorus are the main substances contributing to nutrient enrichment. This metric is expressed in terms of N, NO_3^- or PO_4^{3-} equivalents.

(3) Land use

It is quite apparent that land use is intimately connected with biomass systems. Several methods have been proposed for land use impacts: impacts of land occupation (Guinée et al., 2002), soil degradation (Wegener et al., 1996; Mattsson et al., 2000), and loss of biodiversity and productivity species (Antón et al, 2005; Goedkoop and Spriensma, 2000; Koellner, 2000; Weidema and Lindeijer, 2001). Even indicators based on ecosystem thermodynamics are being developed (Wagendorp et al., 2006). But there is lack of single definition due to lack of adequate impact indicators and scarcity of data.

Most commonly, land use is characterized by the area of land used (m^2) by the biomass system or total area of different types of land (m^2 forest, m^2 agricultural land, etc.) (Baumann and Tillmann, 2004). Due to competing uses of land, the time component of the land use must also be accounted for. To reflect this, occupancy is characterized as the area of land use for a given period of time (m^2.year).

(4) Combined Ecological Indicators

Parameters such as ecological footprint and human appropriation of net primary production are composite indicators of ecological sustainability encompassing the overall effect of several environmental impacts including land use.

Ecological footprint analysis (EFA) was introduced as a tool for quantifying the biophysical load that human populations or industrial processes impose on ecosystems around the world (Rees, 2006). Recognizing that energy and resource exploitation (and the assimilation of wastes associated with resource consumption) can be associated with a corresponding dedicated land/water ecosystem area, EFA determines the total ecosystem area (hectares) required to produce the resources consumed and to assimilate certain wastes in the production of biomass (Kissinger et al., 2007). In addition to the direct physical land requirement, EFA also includes the land/aquatic ecosystem area required for sustainable assimilation and recycling of GHG was well as nutrient emissions. Thus, in effect, EFA includes global warming, nutrient enrichment and land use in a single metric.

In contrast to the ecological footprint, which accounts for the demand for and supply of land area for maintaining a socio-economic system (or product), the human appropriation of net primary production (HANPP) measures how intensively these land areas are used in terms or ecosystem energetics (Haberl et al., 2004). HANPP is defined as the difference between the net primary production (NPP) of potential vegetation, i.e. the amount of biomass energy that would be available in an ecosystem without human intervention, and the proportion of the NPP of the actually prevailing vegetation remaining in the ecosystem after human harvest has been subtracted (Haberl and Erb, 2007). Like EFA, HANPP considers all three-core functions of ecosystems for humans – resource supply, waste absorption and occupied area for human infrastructure. HANPP is expressed in terms of Joules, kilograms of dry-matter biomass or kilograms of carbon. HANPP is an indicator of the intensity with which land is used in producing biomass. As mentioned earlier, limiting the assessment only to the physical area (m^2) without accounting for the intensity of usage is obviously not sufficient. The species-energy hypothesis holds that species numbers in ecosystems depend on the availability of trophic energy; hence, HANPP may be an important driver of biodiversity loss (Haberl and Erb, 2007).

2.2.2. Economic sustainability indicators

Economic development is the main reason for starting any business venture. Hence, economic viability is the most easily understood of the three pillars of sustainability. Its characterization has been well developed in accounting systems. Economic indicators characterize the competitiveness of the production system and hence its sustainability in general. The farmer will continue operation and invest in ecological sustainability only if the production system is profitable. Economic sustainability will lead to research in market innovations and new technologies including development of new agricultural technologies, innovation in culture techniques, development of new processing techniques, etc.

The specific indicators for agriculture/biomass systems are related to the maintenance of farm revenue at sustainable level, the level of multi-functionality, multiple vertical and horizontal connections with producers, organizations and business partners, continuous supply of agriculture products, profitability, etc. These attributes are characterized by annual turnover, production values, production volumes, percentage contribution of income from various services to the total, share of production cost due to energy, environment and staff, profitability of the enterprise, level of production per unit labour and efficient use of fertilizers.

Economic sustainability of biomass utilisation needs to be assessed at the national as well as local levels. For example, at the national level biofuel production from local resources will help to reduce fossil imports and contribute to energy security. Also, investing in locally produced fuels will generate increased employment in rural areas thus internalizing the economic value of the fuels.

The reduced fossil imports can be expressed in terms of foreign exchange savings per unit investment in the biomass project and per unit area of biomass planted. So the unit of such an indicator would be $USD_{saved}/(USD_{invested}\times ha_{plantation})$.

At the local level, the economic sustainability indicator could be total value added from the biomass project per unit investment in the biomass project and per unit area of biomass planted. As in the case of the reduced imports indicator above, the unit of the local value added indicator would be $USD_{value\text{-}added}/(USD_{invested}\times ha_{plantation})$.

2.2.3. Social sustainability indicators

From the point of view of the local communities, social sustainability entails employment and stability of livelihood whereas from the point of view of consumers it means quality of the product and public acceptance of biomass activities. A livelihood is considered sustainable when it can cope with and recover from stresses and shocks (drought, pests, price volatility, etc.), i.e. it is resilient. The livelihood of the poor in agricultural areas is directly dependent on the maintenance of local ecosystem goods and services and thus linked to ecological sustainability. The improved integration of agricultural activities in local society reduces conflicts with other stakeholders.

Social sustainability indicators are difficult to quantify and are often qualitative. Some of the indicators are as follows: economic and social contribution to local society; age, gender and education level of people involved in agriculture and related activities; and measurement of society acceptance (Anon, 2005).

A quantitative indicator for social sustainability assessment could be the number of jobs per unit investment or unit area. The Food and Agriculture Organization of the United Nations has identified a similar indicator, agricultural population per cultivated hectare.

The Human Development Index (HDI) developed by the United Nations combines many of the social issues of importance such as equity in wealth distribution, access to education and quality of life. The marginal HDI could possibly be used as a social sustainability indicator for a biomass project at the local or regional level. However, further research is needed to establish the methodology since the HDI as defined presently is relevant at the national level.

2.3. Integration of sustainability indicators

The sections above present a suite of indicators for assessing ecological, economic and social sustainability of biomass utilisation. The indicators are summarized in Table 2.1 for quick reference. It must however be appreciated that not all the indicators presented above are relevant for every situation; the choice of indicators to be used is case-specific. Indicators such as eco-efficiency have been developed which combine environmental and economic sustainability whereas others such as employment generation combine social and economic sustainability. To facilitate decision-making there may be a need for developing an integrated indicator which could combine ecological, economic and social sustainability.

Table 2.1: Summary of sustainability indicators

Aspect	Indicator	Unit
Ecological	Net Energy Balance (NEB)	MJ
	Net Energy Ratio (NER)	-
	Net Exergy Balance (NExB)	MJ
	Carbon Footprint	$kgCO_2$-eq
	Eutrophication	kgN, NO_3^- or PO_4^{3-}-eq
	Land use	$m^2 \cdot y$
	Ecological Footprint	$m^2 \cdot y$
	Human Appropriation of Net	kg-dry matter biomass or kgC
Economic	Reduced Fossil Imports	$USD_{saved}/(USD_{invested} \times ha_{plantation})$
	Total Value Added	$USD_{value\text{-}added}/(USD_{invested} \times ha_{plantation})$
Social	Employment Generation	No. of jobs/$(USD_{invested} \times ha_{plantation})$

References

Anon, 2005. Defining indicators for sustainable aquaculture development in Europe, CONSENSUS – A multi-stakeholder platform for sustainable aquaculture in Europe, Workshop report, Oostende, Belgium, November 21-23, 2005.

Antón, A., Castells, F., Montero, J.I., 2007. Land use indicators in life cycle assessment. Case study: The environmental impact of Mediterranean greenhouses. *Journal of Cleaner Production*, 15(5), 432-438.

Baumann, H., Tillman, A-M., 2004. The Hitch Hiker's guide to LCA: an orientation in life cycle assessment methodology and application, Student Literature AB, Lund, Sweden.

Dewulf, J., Bösch, M. E., Meester, B. D., Vorst, G. V. d., Langenhove, H. V., Hellweg, S., Huijbregts, M. A. J., 2007. Cumulative Exergy Extraction from the Natural Environment (CEENE): a comprehensive Life Cycle Impact Assessment method for resource accounting, *Environmental Science and Technology*, 41(24), 8477-8483.

Dewulf, J., Van Langenhove, H., 2006. Exergy, in: DeWulf, J. and Van Langenhove, H. (Ed.), Renewables-based technology: sustainability assessment. John Wiley & Sons Ltd, England.

Dewulf, J., Van Langenhove, H., Mulder, J., van den Berg, M. M. D., van der Kooi, H. J., de Swaan Arons, J., 2000. Illustrations towards quantifying the sustainability of technology, *Green Chemistry*, 2, 108-114.

Dewulf, J., Van Langenhove, H., Van De Velde, B., 2006. Exergy-Based Efficiency and Renewability Assessment of Biofuel Production, *Environmental Science and Technology*, 39, 3878-3882.

Goedkoop, M., Spriensma, R., 2000. The Eco-Indicator 99: A damage oriented method for life cycle impact assessment. Amersfoort: PRe´ Consultants B.V.

Guinée, J.B., Gorrée, M., Heijungs, R., Huppes, G.R.K., de Koning, A., Wegener Sleeswijk, A., et al., 2002. Handbook on life cycle assessment. Operational guide to the ISO standards, Eco-efficiency in industry and science, Kluwer, the Netherlands.

Haberl, H., Erb, K.-H., 2007. Assessment of sustainable land use in producing biomass, in: DeWulf, J. and Van Langenhove, H. (Ed.), Renewables-based technology: sustainability assessment. John Wiley & Sons Ltd, England.

Haberl, H., Wackernagel, M., Krausmann, F., Erb, K.-H., Monfreda, C., 2004. Ecological footprints and human appropriation of net primary production: a comparison, *Land Use Policy*, 21, 279–288.

Hovelius, K., Hansson, P. A., 1999. Energy- and exergy analysis of rape seed oil methyl ester (RME) production under Swedish conditions, *Biomass and Bioenergy*, 17, 279-290.

Johansson, D.J.A., Azar, C., 2007. A scenario-based analysis of land competition between food and bioenergy production in the US, *Climatic Change*, 82, 267-291.

Kissinger, M., Fix, J. and Rees, W.E., 2007. Wood and non-wood pulp production: Comparative ecological footprinting on the Canadian prairies, *Ecological Economics*, 62, 552-558.

Koellner, T., 2000. Species-pool effect potentials (SPEP) as a yardstick to evaluate land-use impacts on biodiversity, *Journal of Cleaner Production*, 8, 293–311.

Mattsson, B, Cederberg, C., Blix, L., 2000. Agricultural land use in life cycle assessment (LCA): case studies of three vegetable oil crops, *Journal of Cleaner Production*, 8, 283-292.

Nguyen, T. L. T., Gheewala, S. H., Garivait, S., 2007. Full chain energy analysis of fuel ethanol from cassava in Thailand, *Environmental Science and Technology*, 41, 4135-4142.

Nguyen, T. L. T., Gheewala, S. H., Garivait, S., 2008. Full chain energy analysis of fuel ethanol from cane molasses in Thailand, *Applied Energy* (in press)

Prueksakorn, K., Gheewala, S.H., 2008. Full chain energy analysis of biodiesel from *Jatropha curcas L.* in Thailand, *Environmental Science and Technology* (in press)

Rees, W.E., 2006. Ecological footprints and biocapacity – essential elements in sustainability assessment, in: DeWulf, J. and Van Langenhove, H. (Ed.), Renewables-based technology: sustainability assessment. John Wiley & Sons Ltd, England.

Schlamadinger, B., Marland, G. 1998. Some results from the Graz/Oak Ridge Carbon Accounting Model (GORCAM), in IEA, 1998. Greenhouse gas balances of bioenergy systems. International Energy Agency, Paris.

Shapouri, H., Wang, M., Duffield, J.A., 2006. Net energy balancing and fuel-cycle analysis, in: DeWulf, J. and Van Langenhove, H. (Ed.), Renewables-based technology: sustainability assessment. John Wiley & Sons Ltd, England.

Ulgiati, S. A., 2001. Comprehensive energy and economic assessment of biofuels: When "green" is not enough, *Critical Reviews in Plant Science*, 20, 71-106.

Wagendorp, T., Gulinck, H., Coppin, P., Muys, B., 2006. Land use impact evaluation in life cycle assessment based on ecosystem thermodynamics, *Energy*, 1, 112-125.

WCED, 1987. Our Common Future, World Commission on Environment and Development (WCED), Oxford University Press, New York, 400 pp.

Wegener Sleeswijk, A., Kleijn, R., van Zeitjs, H., Reus, J.A.W.A., Meusen van Onna, H., Leneman, H., et al., 1996. Application of LCA to agricultural products.Leiden: Centre of Environmental Science Leiden University (CML), Centre of Agriculture and Environment (CLM), Agricultural-Economic Institute (LEI-DLO).

Weidema, B.P., Lindeijer, E., 2001. Physical impacts of land use in product life cycle assessment. Technical University of Denmark.

CHAPTER 3
ECONOMIC ASPECTS OF BIOMASS UTILISATION

3.1. Introduction

In 2007, Renewable sources supply 11% of the global energy demand. Biomass is by far the largest energy provider contributing a total of 1,150 million tons of oil equivalent (Mtoe) which translates to a 79% share of the total energy supply sourced out from these renewable sources. In terms of final energy consumption worldwide, biomass ranks fourth with a 10% share after the non-renewable fossil fuels such as oil with 34%, coal with 26%, and natural gas with 22% (Blauvelt, 2007).

Biomass refers to organic materials, either plant or animal, which undergoes the process of combustion or conversion to generate energy. Currently, the largest source of biomass is wood. However, biomass energy may also be generated from agricultural residues, animal and human wastes, charcoal, and other derived fuels. Biomass may be used either directly or indirectly. Direct use, more often termed as the traditional use of biomass, primarily involves the process of combustion. The energy that is generated is usually utilised for cooking, space heating, and industrial processes. Indirect use or the modern use concerns the more advanced processes of converting biomass into secondary energy. This includes gasification and electricity generation. In terms of cross-country adoption, the traditional use of biomass is prevalent among the developing countries. According to the Energy Future Coalition, "more than 2.4 billion people, generally among the world's poorest, rely directly on wood, crop residues, dung, and other biomass fuels for their heating and cooking needs". The modern or commercial use of biomass is more observable in industrialized countries such as the U.S. and in Europe (Blauvelt, 2007).

Renewable energy technologies give rise to economic advantage for two fundamental reasons. First, renewable energy technologies are labour intensive whereas fossil fuels are more capital intensive. Essentially, more jobs per dollar of investment in such technologies rather than conventional electricity generation technologies are created. Second, these technologies utilise indigenous resources. In effect, dollar savings arise from reduced fuel imports. According to the Wisconsin Energy Bureau, the favourable economic impacts of renewable energy are maximized when locally available resources can be substituted for imported fuels at a reasonable price and have a great supply in-state. Furthermore, renewables can create three times as many jobs as the same level of spending on fossil fuels (NREL, 1997).

The Biomass Energy Resource Centre (BERC), an independent, non-profit organisation that assists communities, schools and colleges, state and local governments, businesses, utilities, and others in the development of biomass energy projects, enumerates the positive impacts of biomass energy on local and regional economic development as follows:

- Creation and perpetuation of jobs in the region's economy since biomass fuel is locally produced, harvested, and processed
- Dollars spent on fuel are kept in the local economy compared with fossil fuel systems which generally export fuel dollars
- Employment generation in the regional economy through the building and maintenance of biomass energy systems

- Growth of the whole regional forest products industry (creation of new local markets) by adopting new ways of utilizing forest byproducts for fuel
- Generation of important local, state, and federal tax revenues due to all the jobs and economic activity created by biomass projects

The multiplier effect illustrated in Figure 3.1 causes different types of economic benefits as a result of investments in renewable energy technologies:

- Direct effects — these are on-site jobs and income created as the result of the initial investment; the people who assemble wind turbines at a manufacturing plant, for example.
- Indirect effects — these are additional jobs and economic activity involved in supplying goods and services related to the primary activity; people such as the banker who provides loans to the plant's owners, and the workers who supply parts and materials to the turbine assemblers.
- Induced effects — this are employment and other economic activity generated by the re-spending of wages earned by those directly and indirectly employed in the industry; jobs created by the manufacturing plant workers spending their wages at the local grocery store, for example.

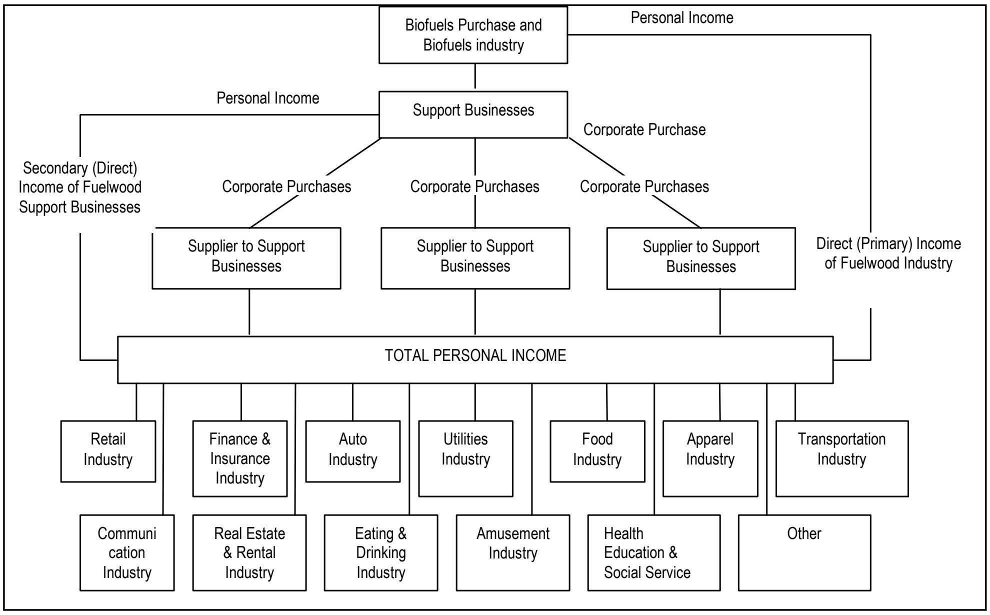


Figure 3.1. The Economic Ripple Effect of the Fuel Wood Industry

Source: National Bioenergy Industries Association

In view of contributing to policy decisions regarding sustainable development, socio-economic and environmental impacts of biomass use must be evaluated. Impacts of increased biomass use on agricultural markets, prices, land availability for food and food security are among the emerging and pressing issues that need to be addressed.

Economic and environmental benefits of biomass utilisation vary at each scale or level of analysis. Values of benefits and costs vary by individual, community, or nation and by firm or industry. In assessing the economic benefits of biomass use, it is important to consider several levels - a) the individual facility level); b) the community level; and c) the national level. Results at the national level can be pooled to present the global status.

At the individual level (i.e. use of a conversion facility or a dedicated energy farm production), the main focus is the profitability of using biomass energy systems compared to alternative energy systems (primarily fossil fuel systems) or of the replacement of conventional crop production with dedicated energy crop production.

At the community level (i.e. interaction of farms/facility with each other, and their interactions with and impacts on local infrastructure, institutions, and economic base), the number and quality of jobs produced or lost, impacts on the tax base, and changes in infrastructure (e.g., roads, schools, waste management facilities, water and sewer, etc.) needs and costs are the basis for economic valuation.

At the national level (i.e. interaction of all farms/facility and users resulting from the production and use of bioenergy, and the interactions and effects on national institutions), of interest are the total economic value added (gross domestic product); trade balance; job creation (loss); impacts on government expenditures; the cost and economic impact of maintaining national security; and the economic cost and effectiveness of environmental regulation.

Assessing patterns in the role of biomass in today's developing economies in East Asia can be done at the national level by looking at the history in the countries that have long time series data. The countries considered in this study are: China, India, Japan, Korea, the Southeast Asian[1] nations, including New Zealand, and Australia.

The succeeding sections present a review of the economic aspects of biomass energy use; the past, present and future situation in the said countries in terms of; and an analysis of biomass contribution to the economy in terms of GDP, employment, energy security, and dollar savings.

3.2. Review of Economic Aspects of Biomass Energy Use

This section presents a review of available literature on the economic aspects of biomass utilisation.   It is not uncommon to note an enumeration of the advantages of biomass use in most literature, yet this report focused more on the viewed economic benefits.   Economic studies on the impact of biomass use are likewise presented and summarized.

3.2.1. Economic Advantages

Modern use of biomass energy has been increasing worldwide. In many countries, it has been made a focal point of renewable energy plans and policies. This is because of several advantages that modern bioenergy offers compared to fossil fuels and/or other renewable energy sources.

Biomass can provide all the major energy carriers—electricity, gases, liquid fuels for transport and stationary uses, and heat on a decentralized (standalone) basis at scales of 10s or 100s of kilowatts (kW) and upwards. It therefore has great potential to

[1] Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand, and Vietnam

substitute fossil fuels or other energy supplies in many contexts. Modern bioenergy technologies can also replace traditional cooking fuels with clean, smokeless, efficient and easily controlled liquid and gas alternatives based on renewable biomass rather than fossil fuels. Substitution of fossil fuels by biomass can lead to significant dollar savings.

The added value and income generation due to bioenergy systems is often retained locally, thereby helping reduce rural poverty. Indeed, modern bioenergy is viewed as a key means of promoting rural development (UNDP, 1995; Ravindranath and Hall, 1995; Kammen et al., 2001, Utria and Williams, 2002). In developing countries, modern bioenergy can provide a basis for rural employment and income generation. For many forestry and agroprocessing industries, biomass serves as an abundant, dependable and cheap fuel which can reduce energy costs.

Since biomass production is labour intensive, feedstock production could be an important source of both primary employment and supplemental income in rural areas. Many farmers could sell farm residues or even purpose-grown wood. Biomass production can be a new source of revenue. Indirectly, other rural enterprises can benefit from biomass feedstock production activity especially providers of agricultural inputs such as fertilizer, suppliers of farm equipment, transporters and marketers of goods. Employment is also generated in processing biomass and working at the bioenergy conversion facility.

Despite these potential advantages, expanding bioenergy use will not automatically contribute to sustainable development. Negative effects on food and the environment are threatening to offset the positive effects on welfare as an energy source. Bioenergy fuels are intensive in the use of inputs, which include land, water, crops, and fossil energy, all of which have opportunity cost. Understanding how bioenergy will affect resource allocation, energy and food prices, technology adoption, and income distribution, etc., is thus essential.

3.2.2. Economic Studies on the Impact of Biomass

Economic studies use a number of techniques to model the impacts from different angles. These are microlevel, single sector and multi-sector models. Microlevel models like cost accounting models and models of technology adoption and resource allocation are useful for calculating the economics of bioenergy from the perspective of an individual economic agent. Sector models are often used from a policymaker's perspective. They are meant to assess the aggregate response of the entire sector to a policy, such as pollution taxes and standards, blending mandates, trade regulations, etc (World Bank, 2007).

We can apply input-output (I-O) models in economic general equilibrium analyses to simulate multi-sector behaviours. It mathematically portrays the transactions among various industries as these industries provide goods and services for consumers, businesses, and government. It provides a systematic method of analyzing inter-industry relationships, thus describing the complete economic impacts of industry activity. The I-O approach is based on the idea that any transaction is both a purchase and a sale, depending on the point of view. A sale by one merchant is viewed as a purchase by the buyer (US Department of Commerce, 1997). The main purpose of which is to measure the overall economic impact of changes in energy prices on employment, government payments, total economic activity, and balance of trade (Manne, Richels, and Weyant 1979; Bhattacharyya 1996).

It is interesting to note that in the studies reviewed, those that involved microlevel models were conducted in New Zealand, Australia and Asian countries like Malaysia, Indonesia, Philippines and India. I-O models were often used in the biodiesel, ethanol, biomass power industries primarily in the US, EU countries, Brazil, India and Indonesia.

While almost all countries in East Asia and the Pacific have already embarked on their renewable energy and sustainable development strategies, projects that involved biomass utilisation were mostly concerned in establishing economic feasibility so as to influence decisions by an entity (farmer, investor or public sector) whether to venture into such activity or not.

The only studies meant to assess biomass contribution to economy in this region are: the assessment of the Indonesian palm oil industry (Kehati, 2006); the macroeconomic trends in biomass intensity and GDP ratio in developing economies in Asia (Victor and Victor, 2002); the assessment of economic contribution of sustainable energy industries in Australia (Mark Ellis and Associates, 2002); and the impact of IREDA funded biomass power and cogeneration projects in India (Rajkumar, 2004).

Studies on bioethanol production show significant impacts to labour income, tax revenues and employment. The Renewable Fuels Association (2004) estimated 694 total jobs out of a 40 million gallon per year ethanol plant and average tax receipts of $1.2 million. Resource Systems Group, Inc. (2000) estimated a range of $170M -

$200M labour income and 4000-6000 total jobs from a 50 million gallon per year ethanol plant. Likewise, total direct employment of 4752 and 9906 jobs would be generated from a 200 million gallon and 400 million gallon per year ethanol plants in California, respectively (California Energy Commission, 2001). In Brazil, a large scale expansion of ethanol production were assessed with the annual production assumed to increase by 104.55 billion liters in 20 years, so as to replace 5% of the estimated global demand for gasoline in 2025. Economic impacts due to the installation of 615 autonomous distilleries (each produces 170 million liters of ethanol from 2 million tonnes of sugarcane yearly) with an estimated investments of R$ 195.81 billion (2005 values), on the average, would generate about 487,300 jobs and a GDP increase of R$ 12.47 billion (2002 values). Operations-related impacts yields an 11.4% increase in GDP (R$ 153.75 billion) and 8% increment in employment (5342 jobs) (Scaramucci and Cunha, 2006).

Studies on biodiesel facilities likewise yield jobs thus contributing to local economy. In Vermont, USA, direct and induced output ranges from approximately $14 million to over $30 million, or approximately 3-6% of the total system output. The biodiesel facility and oilseed processor are predicted to generate about 764 new jobs in the state (Mulder, 2004).

The U.S. biodiesel industry is comprised of 65 manufacturing plants with annual capacity of 395 million gallons per year in 2006. If all new construction and expansion projects are completed and come on line, they will add an estimated 714 million gallons of capacity. The existing and new biodiesel plants will spend $7.6 billion (2005 dollars) on goods and services between 2006 and 2015. Feedstock costs (soybean oil and other feedstocks) are the largest component of operating costs, accounting for about 80 percent of production costs. These expenditures will add $15.6 billion (2005 dollars) to GDP between 2006 and 2015, increase household income by almost $5.4 billion (2005 dollars), and support the creation of as many as 27,400 jobs in all sectors of the economy (LECG, 2006).

Studies that analyze the impacts of policy options in bioenergy use are also in this review. To encourage biofuel policy in the EU, CEC (2006) assessed the impacts of three policy options: 1) Business as usual; 2) Regulated market-based approach; and 3) Deregulated market approach. Option 1 **(**where biofuels directive stand as it is at the time of study) would result in direct employment effects of 34000 full time jobs per year. Option 2 (which encourages biofuels projects, promotes biofuels assistance projects in developing countries) would result in more than 100,000 jobs or a potential to create an additional 67,000 jobs (direct employment), most of which would be in rural regions. Option 3 (which will phase out energy crop premium and tariff duties on biofuels and biofuel feedstocks by 2010 at the latest) would have a similar positive effect on employment in agriculture as option 2, because potential additional employment is linked to an expanded land use and in both cases the area currently set-aside would be reused.

Most studies found in literature involving I-O models focus on the economies of the United States and the EU and have not considered in detail the conditions in developing countries. Moreover, the distribution of the impacts within a given sector of the economy is rather implicit. Microlevel studies or cost-benefit analysis of a bioenergy venture predominates in the developing countries in Asia. Such studies do not actually assess the impact of biomass use to the local economy. Most of the studies estimated positive effects of policies and ethanol and bio-diesel production to local income, taxes and rural employment (direct or indirect).

These impacts however were mostly based on US, EU studies. Hence there is need for developing countries in Asia to employ the models used in the studies to come up with a developing economy perspective on biomass production and use. At the microlevel, there is need to conduct studies that would lead to the adoption of biomass technologies by farmers, processors, and consumers. There is little understanding of the timing, location, and extent of adoption. There is little or no treatment of the cost of environmental externalities, which could greatly affect economic analysis.

3.3. Analysis of Biomass Contribution to Economy

In order to analyze biomass contribution to economy in the East Asian countries considered, a macro-economic approach was used. Data on biomass share in energy mix and GDP per capita were obtained from online statistical databases. The limitation of such analysis is that reported statistics on energy use normally do not include traditional or non-commercial uses of biomass, hence reports of biomass share in some countries do not depict the actual scenario. Nevertheless, certain degree of correlation could still be deduced from the succeeding analysis.

3.3.1. Gross Domestic Product

Victor et al (2002) projected biomass intensity and GDP ratio for selected developing countries in Africa, Asia and Latin America. A steady and rapid improvement of biomass intensity for all countries was seen. A rise in income yields to a decline in biomass intensity. The rate of change varies considerably. However in Thailand and China, the rate of increase in biomass intensities was 8 percent annually

Victor et al (2002) also looked into the pattern of biomass use and incomes in developing countries[2]. Using 1996 data, it was observed that as income increased, the share of fuelwood in total household energy consumption declined. The exact share of fuelwood varied greatly across countries, but the declining pattern of fuelwood share with income was specific at low income levels. Furthermore, for countries with high per capita income, industrialization and urbanization, the share of biomass in energy consumption is smaller. In the countries with low per capita incomes, the share of biomass in total energy can reach 80% or more. On one hand, US historical data confirm that with socio-economic development, households and industries move from low-quality fuels, such as traditional biomass, to more convenient and efficient fuels, such as kerosene, coal, oil, gas and electricity.

In Table 3.1, the value of the wood energy contribution to the Asian countries' Gross Domestic Product (GDP) is observed. Economic growth could be achieved through increases in a country's GDP. The data covers the years 1998, 2000, and 2002. Among the Asian countries, the largest earner from wood energy was consistently China, followed by India and Indonesia.

---

[2] Includes Nepal, Bhutan, Laos, Bangladesh, Vietnam, Cambodia, Pakistan, India, Sri Lanka, Indonesia, Maldives, Philippines, China, Thailand, Malaysia

Table 3.1. Gross domestic product (in US$ million) – wood energy activities[3]

Country	1998	2000	2002
Bangladesh	44,092	47,181	47,328
Bhutan	403	484	594
Cambodia	3,035	3,367	3,677
China	946,301	1,080,429	1,237,145
India	413,813	460,616	515,012
Indonesia	95,446	150,196	172,911
Laos	1,285	1,711	1,680
Malaysia	72,175	90,041	95,157
Maldives	540	624	618
Myanmar	NA	NA	NA
Nepal	4,892	5,480	5,493
Pakistan	62,228	60,756	60,521
Philippines	65,172	74,862	77,076
Sri Lanka	15,795	16,305	16,373
Thailand	115,849	120,968	126,407
Vietnam	27,150	31,168	35,110

Source: World Bank, 2002

Conservation and Development Specialist Foundation (CDSF, 2007) case study evaluated the economic impacts of biomass in the Philippines in terms of value addition accumulated from rice and coconut conversion or processing.

The final value added amounted to PhP10.14 or US$0.24 (US$= PhP42) per kilogram of mature coconut processed into coconut methyl ester (Table 3.2) for a total

[3] Refers to different wood-based fuels which include fuelwood (cut directly from trees and forests); charcoal and wood-derived fuels and by-products of forest processing industry such as black liquor and other wood residues.

value added of PhP7,068,000,000 or US$ 168,000,000 (Table 3.4). Total value addition for rice amounted to PhP7.13 or US$0.1698 per kilogram of palay processed into milled rice (Table 3.3) for a total value added of PhP882,996 or US$21,023 (Table 3.5). The computed values already include the profits generated out of the by-products of rice and coconut processing.

Table 3.2 Summary of value added (in PhP) by product form produced from a kilo of mature coconut.

PRODUCT FORM	GROSS REVENUE (in PhP)	PRODUCTION COST (in PhP)	PARTIAL VALUE ADDED	VALUE ADDED FROM BY-PRODUCTS				FINAL VALUE ADDED
				Husk	Shell	Copra Meal	Glycerin	
Mature Coconut	5.00	2.42	2.58	1.09	—	—	—	3.67
Copra	7.20	3.93	3.27	1.09	0.19	—	—	4.55
Unrefined Oil	11.52	6.22	5.30	1.09	0.19	0.24	—	6.82
Coconut Methyl Ester	16.74	9.39	7.35	1.09	0.19	0.24	1.26	10.14

Table 3.3. Summary of value added for the different sectors in rice trading.

SECTOR	GROSS REVENUE (in PHP/KG)	PRODUCTION COST (in PHP/KG)	PARTIAL VALUE ADDED	VALUE ADDED FROM BY-PRODUCTS Husk & Bran	FINAL VALUE ADDED
Production	9.00	6.50	2.50	—	2.50
Up to Milling	13.44	8.47	4.97	0.71	5.68
Up to Wholesaling	14.56	8.76	5.80	0.71	6.51
Up to Retailing	15.68	9.26	6.42	0.71	7.13

Another important economic contribution of biomass is in terms of tax revenues generated from the different entities within the industries as estimated in the CDSF case study. The income generated from mature nut, copra, unrefined oil, and methyl ester productions amounts to PhP7,216 million per year. Adding this value to the net profit generated from all by-products gives the total annual income of PhP7,068 million from the coconut industry. Taxes are set at 32% of the total taxable income. Coconut farmers are exempted from paying taxes, hence, only the copra producers, unrefined oil producers, and methyl ester producers are subjected to 32% income tax. Total tax revenues amount to PhP1,380 million or US$33 million annually (Table 3.4).

By adding the income generated out of the sale of by-products, the total annual net income generated out of the rice industry in Quezon was ultimately valued at PhP882,996. Total taxable income is set at 32%. Since the farmers are exempted from paying taxes, total tax revenues from the rice industry amounts to PhP179,834 or US$4,281 annually from tax dues paid by the millers, wholesalers, and retailers (Table 3.5).

Table 3.4 Total annual net income and taxes generated from coconut production and processing in Quezon.

PRODUCT FORM	Total Net Profit (M PhP)	Taxes Paid (M PhP at 32%)
Mature Coconut	2,755	exempted
Copra	674	215.56
Unrefined Oil	1,703	545.01
Coconut Methyl Ester	1,936	619.62
ALL	7,068 $168	1,380.19 $33

Table 3.5. Total annual net income and taxes generated from rice production and processing in Quezon

SECTOR/OUTPUT	NET PROFIT (in PhP)	TAXES PAID (in PhP at 32%)
Farmer/Wet Palay	321,013	exempted
Miller/Milled Rice	411,348	131,631
Wholesaler/Milled Rice	70,248	22,479
Retailer/Milled Rice	80,387	25,724
ALL SECTORS	882,996 US$21,023	179,834 US$4,281

3.3.2. Employment

Employment impacts could be well assessed through I-O models, however, to represent microlevel activities effects to other sectors is rather complicated. First, employment impacts (direct and indirect) are specific to a biomass generation facility, and so to come up with a total employment impact from all facilities, I-O analysis must be conducted to every specific type. Extrapolation is possible to same facilities of different capacities; however, the input requirements would be enormous. Additional literature on employment impacts were thus resorted to.

In terms of employment generation, global scenarios differ with respect to biomass utilisation. For developing countries, the traditional way of using biomass energy is prevalent. The rapid population growth entails great pressure on the countries' existing resources with the persistence of such trend in biomass utilisation. In contrast, developed countries give weight on investing in research and development for further advancement of biomass technology (Domac, 2004).

The use of wood and some other forms of biomass energy generates at least 20 times more local employment within the national economy than any other form of energy, per unit. A large amount of unskilled labour is engaged in growing, harvesting, processing, transporting and trading the fuels, which generates off-farm income for rural populations, either regularly or off-season (FAO, 1997).

Estimated employment figures among various developing countries due to production and distribution of bioenergy resources are shown in Table 3.6.

Table 3.6 Estimated employment figures among various countries

Country	Estimated Employment Figures	Description and Nature of Employment
Pakistan	600,000	Wholesalers, retailers in the WF trade. Many are involved in production, conversion, and transportation. About three-quarters are full time, the rest part time. The ratio between traders and gatherers is 1:5
India	3–4 million	The woodfuel trade is the largest source of employment in the energy sector
Philippines	700,000 hhs (productions) 140,000 hhs (trade)	Biomass energy production and trade

Source: Domac, 2004

A more detailed account of job creation, earnings and employment in bioenergy projects is presented in Table 3.7. Three types of systems are shown here: intensive production in marginal lands, woodfuel production with intensive inter-cropping, and large-scale woodfuel production on previously forested lands. Total employment per unit of energy in person-years was derived for the activities of establishment, weeding, harvesting, chipping and administration.

Table 3.7 Employment and earnings from selected studies among developing/tropical countries (partial) biofuel production

Type	Establishment	Weeding	Harvesting	Transport	Chipping	Administration	Total
				Person years/PJ			
Intensive production, farmers	112	338	248	70	13	19	799
Intensive inter-cropping	71	196	251	71	13	19	620
Large-scale "energy forestry"	34	59	85	51	13	11	252
				Earnings $ per PJ			
Intensive production, farmers	82,305	205,761	257,202	68,587	13,717	68,587	696,159
Intensive inter-cropping	54,870	126,886	257,202	68,587	13,717	68,587	589,849
Large-scale "energy forestry"	17,147	27,435	37,723	20,576	13,717	34,294	150,892

Source: Domac, 2004

Domac (2004) also highlighted that the use of renewable energy technologies will more than double by 2020 and will lead to the creation of about 900,000 jobs. An approximate of 500,000 of the total number of projected jobs will be in the agricultural industry in order to provide the primary biomass fuels (Table 3.8).

Table 3.8 Impact on employment in renewable technologies for European Union

	2005	2010	2020
Solar thermal heat	4,590	7,390	14,311
Photovoltaics	479	−1,769	10,231
Solar thermal electric	593	649	621
Wind onshore	8,690	20,822	35,211
Wind offshore	530	−7,968	−6,584
Small hydro	−11,391	−995	7,977
Bioenergy	449,928	642,683	838,780
Total	453,418	660,812	900,546

Source: Domac, 2004

Melhuish (1998) estimated the contribution of energy systems to sustainable development in New Zealand. There were a total of 12,920 jobs and 9,900 jobs in the energy sector in 1990 and 1996, respectively. These data show a 23% decline in 6 years or 3.8% annually. Out of these totals, 4.6% (600 jobs) and 8.1% (800 jobs) were in the energy efficiency and renewable energy sector in 1990 and 1996, respectively.

In Australia, Gerardi (2006) reported the economic contribution of renewable energy technologies in three sectors namely generation, manufacturing, and services. The renewable energy industry generates a total of 6,212 direct jobs and 9,069 indirect jobs. Of these totals, the leading contributor is bioenergy which renders 27.4% (1,813 direct jobs) and 29.3% (2,664 indirect jobs) (Table 3.9).

Table 3.9. Economic contribution of renewable energy technologies in Australia, 2005

Technology	Current capacity (MW)	Committed capacity (MW)	Total assets ($million)	Total revenue ($million/yr)	Direct jobs	Indirect jobs
Bioenergy	566	130	626	304	1,813	2,664
Hydro	6,989	156	6,234	985	1,655	1,510
Wind	561	338	864	252	956	1,802
Wave	1	1	6	1	4	6
Solar heater	Na	na	na	106	1,000	1,772
PV solar	46	na	10	220	1,185	1,316
TOTAL	8,612	625	7,740	1,866	6,212	9,069

Source: Gerardi (2006)

A Philippine case study conducted by CDSF (2007) estimated the employment impacts in terms of the man-day requirement of biomass-based industries. Results showed that biomass-based industries such as coconut and rice could generate a total of 6,591,174 man-days (Table 3.10) and 2,867,437 man-days (Table 3.11) in a year, respectively.

Table 3.10. Summary of annual employment generation product form in coconut industries in Quezon, Philippines.

PRODUCT FORM	TOTAL OUTPUT IN QUEZON (in MT)	LABOUR REQUIREMENT (in mandays)
Mature Coconut	750,155	3,439,864
Copra	300,062	1,500,310
Unrefined Oil	270,056	1,500,310
Coconut Methyl Ester	270,056	150,691
TOTAL EMPLOYMENT (mandays)		6,591,174
Employment per Hectare (mandays)		33.56
Number of Labourers Employed (total)		27,464

Table 3.11. Summary of annual employment generation per palay/rice operation in Quezon, Philippines.

OPERATION	TOTAL OUTPUT (in MT)	LABOUR REQUIREMENT (in mandays)
Palay Production	128,405	2,504,370
Rice Processing	120,701	241,401
Rice Marketing (Wholesaling and Retailing)	72,420	121,666
TOTAL EMPLOYMENT (mandays)		2,867,437
Employment per hectare (mandays)		75.24
Number of labourers (@ 240 mandays /yr)		11,948

Employment impacts of biomass use are actually modest compared to other sectors of economy. However, unique to the sector is its ability to stir rural economy and development. When a biomass facility has great potential for replication in different rural areas, even the smallest of impacts could be magnified and significantly contribute to the national economy.

3.3.3. Energy Security and Dollar Savings

Wood and other types of biomass are widely used as fuels in the private and industrial sectors, basically because they are cheaper than other fuels. Local availability and reliability of supply add to the economic advantages. Modern applications in both industrialized countries and in South-East Asia have demonstrated that biomass energy can also be competitive for larger-scale industrial applications. For fuel-importing countries, the use of local biomass can save substantial amounts of foreign exchange.

Presently, it is anticipated that shifting to renewable energy could save countries in East Asia as much as two trillion US dollars in fuel costs over the next 23 years, or more than 80 billion dollars annually, according to the environmental group Greenpeace. As projected by the International Energy Agency (IEA), investment costs for new power plants in East Asia would total 490 billion dollars between 2004 and 2030. However, under the Greenpeace scenario, investment costs on renewable energy would amount to 556 billion dollars over the same time frame. The IEA projections stated that fuel costs would amount to $6.3 trillion over a 23-year period. Nonetheless, if East Asian countries shifted to renewable energy, fuel costs over the same period would total $4.2 trillion dollars, translating into savings of $2.1 trillion (Terra Daily, 2007).

The Philippines is one of the countries which are heavily dependent on imported fuels. As a result, the national government is continuously promoting the utilisation of indigenous renewable sources such as coconut methyl ester as diesel enhancer. With such advocacy, diesel imports could be reduced significantly which translates to dollar savings. CDSF (2007) estimated that 270,058 MT of coconut methyl ester produced in the chosen study area could generate US$80 million worth of savings from reduced diesel imports (Table 3.12). Biomass-based product development is a great opportunity for an agricultural country like the Philippines to exploit its vast biomass sources.

Table 3.12 Annual foreign exchange savings from CME production to replace diesel.

ITEM	VALUE
Forex savings per diesel displacement (US$/li)*	0.64
Volume of CME produced in Quezon (MT)	270,058
Volume of CME (MT) consumed locally (40%)	108,023
Volume of diesel (in liters) to be displaced at 1% blend	125,608,372.09
Total forex savings (US$)	80,389,358.14

Note: *Based on Dept of Energy's computation, 2007

3.4. Summary and Conclusions

In 2007, Renewable sources supply 11% of the global energy demand. Biomass is by far the largest energy provider contributing a total of 1,150 million tons of oil equivalent (Mtoe) which translates to a 79% share of the total energy supply sourced out from these renewable sources. In terms of final energy consumption worldwide, biomass ranks fourth with a 10% share after the non-renewable fossil fuels such as oil with 34%, coal with 26%, and natural gas with 22% (Blauvelt, 2007).

Biomass energy benefits the local and regional economic development through creation and perpetuation of jobs since biomass fuel is locally produced, harvested, and processed. It also keeps fuel dollars in the local economy unlike with fossil fuel systems which generally export fuel dollars. It also leads to development of new local markets by adopting new ways of utilizing forest byproducts for fuel. Moreover, tax revenues are also generated due to all the jobs and economic activity created by biomass projects

A review of available literature on economic studies on biomass use was conducted. The studies covered in this review are not exhaustive, but they somehow represent works on the economic impacts of biomass use in developed countries and in some developing economies of Asia. The economic studies on biomass involve 3 types: microlevel studies which provide point estimates of average costs and profitability of biomass production; sector-wide studies that analyze the impacts of policies at the sector or economywide level; multisector studies that analyze inter-industry relationships, thus describing the complete economic impacts of an industry or a biomass production facility.

Most studies found in literature involving I-O models focus on the economies of the United States and the EU and have not considered in detail the conditions in developing countries. Most of the studies estimated positive effects of policies and ethanol and bio-diesel production to local income, taxes and rural employment (direct or indirect). Microlevel studies or cost-benefit analysis of a bioenergy venture predominates in the developing countries in Asia. Such studies do not actually assess the impact of biomass use to the local economy.

These impacts however were mostly based on US, EU studies. Hence there is need for developing countries in Asia to start assessing the economic impacts of biomass use to come up with a developing economy perspective.

To assess the role of biomass in today's developing economies in East Asia, the past, current and future trends of biomass utilisation were reviewed. The countries included in the study are: China, India, Japan, Korea, the Southeast Asian nations, including New Zealand, and Australia. To indicate biomass contribution to the East Asian countries' economy, GDP employment, energy security and dollar savings were used.

Past and current trends in biomass energy use in the countries considered generally show a declining share in the energy mix, though the actual figures of consumption are increasing. Fossil fuels remain to be the key fuels.

Employment opportunities (direct and indirect) abound in the biomass energy industry especially in the services sector. The services sector offers the largest employment both in terms of direct and indirect jobs as it encompasses a wide variety of employment opportunities including installation, fuel collection and extraction, distribution and sales, consulting and research and development. Employment impacts of biomass use are actually modest compared to other sectors of economy. However, unique to the sector is its ability to stir rural economy and development. When a biomass facility has great potential for replication in different rural areas, even the smallest of impacts could be magnified and significantly contribute to the national economy.

Taking the case of a developing economy like the Philippines, the economic impacts of biomass production and processing on a micro level were estimated through monetary equivalents. The economic impacts that were assessed were value addition, job creation, tax revenue generation, and foreign trade impacts in terms of dollar earnings and savings. Biomass energy occupies a large fraction in the country's total energy mix. Generally, the overall economic impact of the biomass-based industries was found to be significant. Economic benefits were favourable not only on the provincial or regional level but also to the national economy as a whole.

The potential benefits of biomass energy are extensive. This review has seen a generally positive trend in the macroeconomic indicator (GDP) with biomass share, whereas a number of employment opportunities can be achieved from the industry. For countries who are net importers of fuels, biomass use could not only save them billions of US dollars but also be able to diversify their energy sources and achieve energy security in the long term.

References

Blauvelt, E. 2007. Biomass – The largest source of renewable energy. Retrieved from the World Energy Discussion on-line database on the World Wide Web: http://worldenergydiscussion.blogspot.com/2007/08/biomass-largest-source-of-renewable.html

Bournakis, A.D., Cuttica, J.J. and Mueller, S. 2005. The Economic And Environmental Impacts Of Clean Energy Development In Illinois. Retrieved from the University of Illinois Chicago on-line database on the World Wide Web: http://www.erc.uic.edu/PDF/Clean_Energy_Development.pdf

BP Global. 2006. Statistical Review of World Energy 2007. Retrieved from the BP Global on-line database on the World Wide Web: http://www.bp.com/liveassets/bp_internet/globalbp/globalbp_uk_english/reports_and_publications/statistical_energy_review_2007/STAGING/local_assets/downloads/spreadsheets/statistical_review_full_report_workbook_2007.xls

California Energy Commission. 2001. Costs and Benefits of a Biomass-to-Ethanol Production Industry in Califronia. http://www.energy.ca.gov/report/2001.

Commission of the European Communities. 2006. An EU Strategy For Biofuels Impact Assessment. Retrieved from the European Commission on-line database on the World Wide Web: http://ec.europa.eu/agriculture/biomass/biofuel/sec2006_142_en.pdf

Domac, J. 2004. Socio-economic drivers in implementing bioenergy projects. Retrieved from Science Direct on-line database on the World Wide Web: http://www.sciencedirect.com/

East Harbour Management Services. 2002. Drivers of Woody Bioenergy in New Zealand. Retrieved from the Bioenergy Association of New Zealand on-line database on the World Wide Web: http://www.bioenergy.org.nz/documents/publications/articles/WPS/DriversOfBioenergyInNZ_021114a.pdf

East Harbour Management Services. 2005. Availabilities and Costs of Renewable Sources of Energy for Generating Electricity and Heat 2005 Edition. Retrieved from the NZ Ministry of Economic Development on-line database on the World Wide Web: http://www.med.govt.nz/upload/26015/renewables.pdf

Elauria, M.M., Almazan,P.L.P.,Castro,M.L.,and Elauria,A.J.,2008. Case Study on the Economic Impacts of Biomass Production and Processing in the Philippines.

FAO 1997. Biomass energy in ASEAN member countries. Retrieved from the Food and Agriculture Organization on-line database on the World Wide Web: http://www.fao.org/sd/EGdirect/EGan0008.htm

Gerardi, W. 2006. Renewable Energy - A Contribution to Australia's Environmental and Economic Sustainability. Renewable Energy Generators Australia. Retrieved from the REGA on-line database on the World Wide Web: http://www.rega.com.au/Documents/Publications/J1281%20Final%20Report%20V3.pdf

Judd, B. 2003. Feasibility of Producing Diesel Fuels From Biomass in New Zealand. Retrieved from the NZ Energy Efficiency and Conservation Authority on-line database on the World Wide Web: http://www.eeca.govt.nz/eeca-library/renewable-energy/biofuels/report/feasibility-of-producing-diesel-fuels-from-biomass-in-nz-03.pdf

Kehati. 2006. Indonesian Path Toward Sustainable Energy: A case study of developing palm oil as biomass in Indonesia. The Indonesian Biodiversity-KEHATI; Sawit Watch Social Economic Research Institute–INRISE; Bogor Agricultural Institute Media Indonesia Group/Daily Research & Development. Retrieved from the Both Ends on-line database on the

World Wide Web:
http://www.bothends.org/strategic/061211_Biomass%20case%20study%20Indonesia.pdf

LEGC. 2006. Contribution Of The Biodiesel Industry To The Economy Of The United States. Retrieved from the National Biodiesel Board on-line database on the World WideWeb:http://www.biodiesel.org/resources/reportsdatabase/reports/gen/20060720_gen-371.pdf

Melhiush, M. 1998. Energy for Economic, Environmental and Social Sustainability. New Zealand Report to GEO Project. Sustainable Energy Forum. Wellington, New Zealand. Retrieved from the Helio-International on-line database on the World Wide Web:
http://www.helio-international.org/Helio/anglais/reports/newzealand.html

Mulder, K. 2004. An Ecological Economic Assessment of a Proposed Biodiesel Industry for the State of Vermont. Gund Institute for Ecological Economics Rubenstein School of the Environment and Natural Resources University of Vermont. Retrieved from the University of Vermont on-line database on the World Wide Web:
http://www.uvm.edu/~susagctr/Biomass%2004%20Final%20Report.pdf

National Bioenergy Industries Association, Economic Benefits of Biomass Power Production in the U.S. Reprinted from Biologue Issue Volume 10, Number 1
http://www.nyserda.org/rps/Article.pdf

NREL. 1997. Dollars from Sense: The Economic Benefits of Renewable Energy. Retrieved from the NREL on-line database on the World Wide Web: http://www.nrel.gov/docs/legosti/fy97/20505.pdf

Pang, S. and Li, J. 2005. BIGCC System For New Zealand: An Overview And Perspective. Retrieved from the NZ University of Canterbury on-line database on the World Wide Web: http://ir.canterbury.ac.nz/bitstream/10092/166/1/12603290_Main.pdf

Rajagopal, D. and Zilberman, D. 2007. Review of Environmental, Economic and Policy Aspects of Biofuels. The World BankDevelopment Research Group Sustainable Rural and Urban Development Team. Retrieved from the World Bank on-line database on the World Wide Web: http://www-wds.worldbank.org/external/default/WDSContentServer/IW3P/IB/2007/09/04/000158349_20070904162607/Rendered/PDF/wps4341.pdf

Rajkumar, D. 2004. Biomass Power For Rural Energy And Sustainable Development In India – Role Of Ireda. Retrieved from the Natural Resources Institute on-line database on the World Wide Web: http://www.nri.org/biomass/conference_papers/funding_renewable_energy_programmes_in_india.pdf

Resource Systems Group, Inc. 2000. Economic Impact Of Fuel Ethanol Facilities In The Northeast States. Retrieved from the Northeast Regional Biomass Program on-line database on the World Wide Web: http://www.nrbp.org/pdfs/pub25.pdf

Renewable Fuels Association. 2004. Ethanol Industry Outlook http//www.ethanolrfa.org

Scaramucci, J.A. and Cunha, M.P. Undated. Bioethanol As Basis For Regional Development In Brazil: An Input-Output Model With Mixed Technologies. Retrieved from the Wilson Center on-line database on the World Wide Web: http://www.wilsoncenter.org/news/docs/bioethanol%20regional%20dev%20strategy%20brazil.pdf

Southeast Biomass State and Regional Partnership. 2006. Fact Sheet: Economic Impacts of Bioenergy Production and Use. Retrieved from the Arkansas Energy Office on-line database on the World Wide Web: http://www.arkansasrenewableenergy.org/fact%20sheets/Economics.pdf

Stucley, C.R., Schuck, S.M. Sims, R.E.H., Larsen, P.L., Turvey, N.D. and Marino, B.E. 2004. Biomass Energy Production In Australia: Status, Costs And Opportunities For Major Technologies. Retrieved from the Rural Industries Research and Development Corporation on-line database on the World Wide Web: http://www.rirdc.gov.au/reports/AFT/04-031.pdf

TERRA DAILY. 2007. Renewable energy can save East Asia two trillion US dollars in fuel costs. Retrieved from the Terra Daily on-line database on the World Wide Web: http://www.terradaily.com

United Nations Environment Program. 2007. Analysing our Energy Future: Some Pointers for Policy Makers. Retrieved from the UNEP on-line database on the World Wide Web: http://www.unep.org/pdf/dtie/energyfuture.pdf

Victor, N.M. and D.G. Victor.2002. Macro Patterns in the Use of Traditional Biomass Fuels. Retrieved from the Stanford University on-line database on the World Wide Web: http://iis-db.stanford.edu/evnts/3920/VICTOR_ppr.pdf

Waters, D. and McKissick, J. 2004. An Economic Impact Analysis of a Large-Scale (533 WTPD) Biomass Gasification Facility on Georgia's Economy. Retrieved from the University of Georgia on-line database on the World WideWeb: http://www.agecon.uga.edu/~caed/biomass.pdf

Weisbrod, G. and Lin, X. 1996. The Economic Impact Of Generating Electricity From Biomass In Iowa: A General Equilibrium Analysis. Retrieved from the Massachusetts Institute of Technology on-line database on the World Wide Web: http://ocw.mit.edu/NR/rdonlyres/Urban-Studies-and-Planning/11-482JFall-2005/356A077F-D8CE-41B7-A6FC-E825C0C9B0ED/0/biomass.pdf

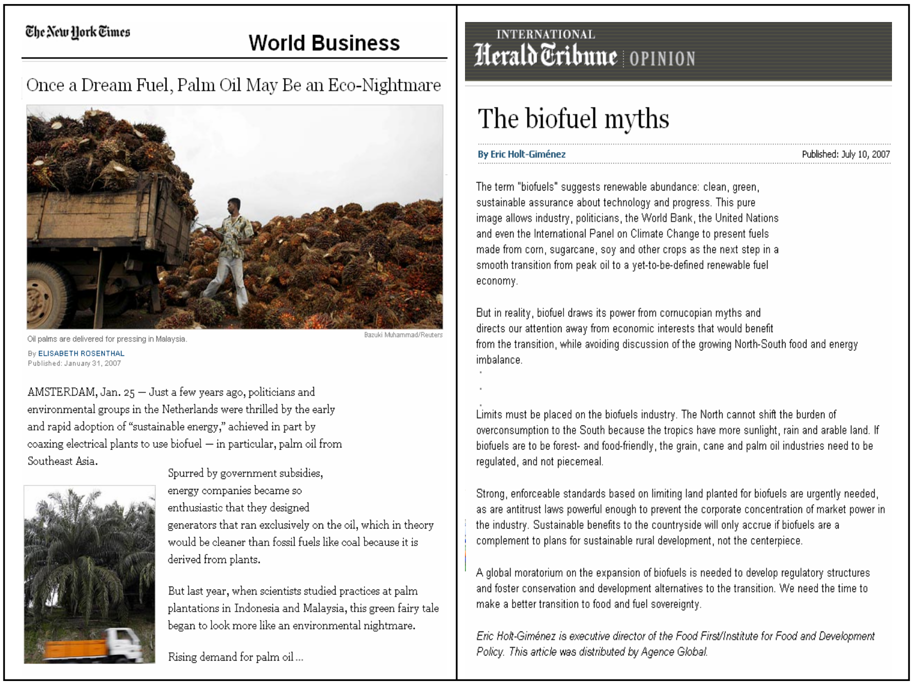
CHAPTER 4
ENVIRONMENTAL ASPECTS OF BIOMASS UTILISATION

4.1. Environmental issues of biomass utilisation

Biofuels are expected to be produced in larger volumes in the coming decades. However, unlike other renewable energy strategies (solar, wind, sea waves), biomass resources are constrained by the availability of land and water. Energy inputs and fertilizers are also required in their growth, cultivation and production. In some cases, biofuels can consume a significant amount of energy that is derived from fossil fuels (Blottnitz and Curran, 2007). Some examples are operation of machinery for cultivating, harvesting and transportation, steam and electricity for processing, etc.

The large scale development of agricultural biomass systems is not without additional emissions and ecological risks. Certain sources of biomass feedstock, especially palm oil, have been subject to much debate as its cultivation is reported to be linked with negative environmental effects such as depletion of land and agrobiodiversity (Mattsson et al., 2000; Kesavan and Swaminathan, 2007). In recent studies on the use of biofuels, the United Nations suggest that as long as biofuels are produced in a sustainable manner, they can bring many positive benefits to society and on the environment (Associated Press, 2007; CBS News, 2007). On the other hand, if not managed properly, issues such as deforestation, water contamination and shortage of food supply can result in severe drawbacks. A collection of news highlighting the concerns involving the use of biomass is displayed in Figure 4.1.

In 2007 it was reported that the value of Malaysia's palm oil exports reached a record high due to strong worldwide demand caused by the boom in biofuels (Channel News Asia, 2007). Another recent article by an energy expert (Cockcroft, 2008) explained that due to the high costs of biomass resources, a few biodiesel plants in Asia have ceased operation. This was triggered by the high demand for crops in Europe and other countries, triggered by the search for alternative fuels. If not selected wisely, bioenergy development may compromise food security and result in environmental damage. The social implications of rising food prices will exacerbate the problem of food shortage, especially among the poor.


The New York Times

World Business

Once a Dream Fuel, Palm Oil May Be an Eco-Nightmare

Oil palms are delivered for pressing in Malaysia. Bazuki Muhammad/Reuters

By ELISABETH ROSENTHAL
Published: January 31, 2007

AMSTERDAM, Jan. 25 — Just a few years ago, politicians and environmental groups in the Netherlands were thrilled by the early and rapid adoption of "sustainable energy," achieved in part by coaxing electrical plants to use biofuel — in particular, palm oil from Southeast Asia.

Spurred by government subsidies, energy companies became so enthusiastic that they designed generators that ran exclusively on the oil, which in theory would be cleaner than fossil fuels like coal because it is derived from plants.

But last year, when scientists studied practices at palm plantations in Indonesia and Malaysia, this green fairy tale began to look more like an environmental nightmare.

Rising demand for palm oil ...

INTERNATIONAL Herald Tribune | OPINION

The biofuel myths

By Eric Holt-Giménez — Published: July 10, 2007

The term "biofuels" suggests renewable abundance: clean, green, sustainable assurance about technology and progress. This pure image allows industry, politicians, the World Bank, the United Nations and even the International Panel on Climate Change to present fuels made from corn, sugarcane, soy and other crops as the next step in a smooth transition from peak oil to a yet-to-be-defined renewable fuel economy.

But in reality, biofuel draws its power from cornucopian myths and directs our attention away from economic interests that would benefit from the transition, while avoiding discussion of the growing North-South food and energy imbalance.

.
.
.

Limits must be placed on the biofuels industry. The North cannot shift the burden of overconsumption to the South because the tropics have more sunlight, rain and arable land. If biofuels are to be forest- and food-friendly, the grain, cane and palm oil industries need to be regulated, and not piecemeal.

Strong, enforceable standards based on limiting land planted for biofuels are urgently needed, as are antitrust laws powerful enough to prevent the corporate concentration of market power in the industry. Sustainable benefits to the countryside will only accrue if biofuels are a complement to plans for sustainable rural development, not the centerpiece.

A global moratorium on the expansion of biofuels is needed to develop regulatory structures and foster conservation and development alternatives to the transition. We need the time to make a better transition to food and fuel sovereignty.

Eric Holt-Giménez is executive director of the Food First/Institute for Food and Development Policy. This article was distributed by Agence Global.

Fig. 4.1: In the news: concerns for biomass utilisation

Source: New York Times; International Herald Tribune

Along with the belief that bio-energy can solve the world's energy crisis, there exists a myriad of interconnected environmental factors that have to be properly managed. The merits of any biomass utilisation for energy production should be assessed alongside a few environmental concerns:

- Deforestation / land use
- Water management
- Fertilizers and pesticides (GAP or Good Agricultural Practices)
- Carbon dioxide emissions / climate change
- Energy balance

At the end of the report, a life cycle approach, overview of present concerns, and the environmental prospects of future biomass utilisation will be discussed.

4.1.1. Deforestation

Deforestation is broadly defined as the clearance of forests by society and the conversion of land to another use, in this case, biomass production. Plantations of agricultural and industrial crops have long been providing new sources of raw materials in Asia and other parts of the world. The Asian region makes up about one-quarter of earth's land area, but holds almost 60% of the world's population. In recent years, the clearing of forest land for agriculture has been cited as the major cause of deforestation (Benhin, 2006).

More land space had to be made available for the expanding oil palm plantations. If this land is created by draining and burning peatland, it will result in huge amounts of carbon emissions into the atmosphere. It is expected that a major switch of using biomass for the production for biofuels – instead of for food – will require huge conversions of agricultural and forest lands to grow these crops on a commercial scale. As it is, satellite data reveal that 40% of the earth's land is already used up for agriculture (Crenson, 2007).

When forests are cleared to convert land for agricultural use, it is common for a large proportion of the above ground biomass to be burned, which rapidly releases carbon dioxides into the atmosphere. Globally, deforestation has been reported to be one of the major contributors to anthropogenic carbon emissions (Bala et al., 2007; Howden, 2007). The Intergovernmental Panel on Climate Change (IPCC) estimates that tropical deforestation was responsible for more about 20-30% of global anthropogenic carbon dioxide emissions during the 1990s (Bonnie et al., 2000).

Figure 4.2 shows the tropical deforestation by region for years 1990 - 2005, and Figure 4.3 shows the average annual forest loss for 25 countries (including Indonesia, Philippines and Malaysia) for years 2000 - 2005, based on data from the U.N. Food and Agriculture Organization (FAO, 2008).

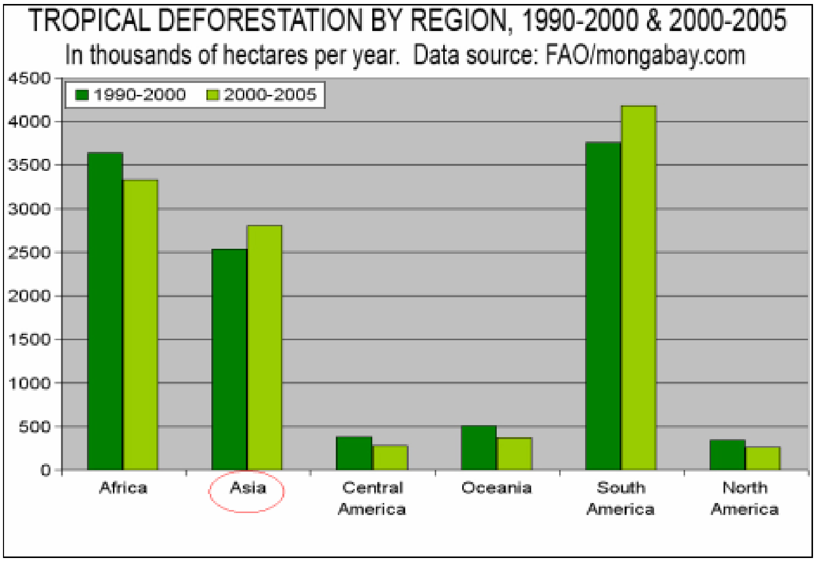


Fig. 4.2: Tropical deforestation rates by region

Source: FAO

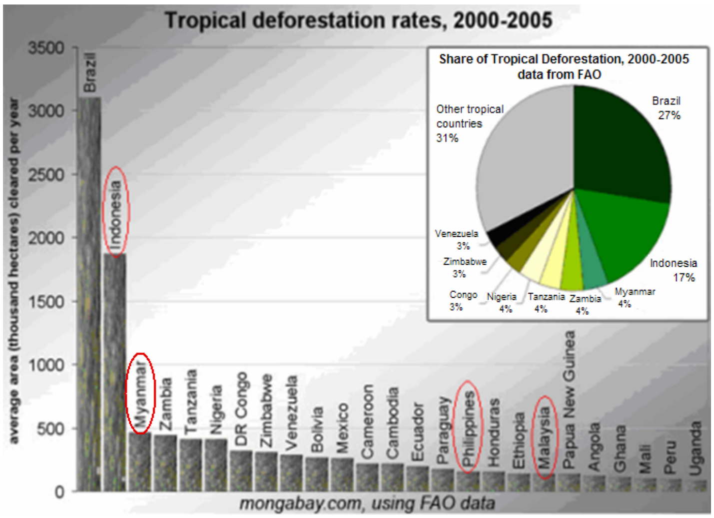


Fig. 4.3: Tropical deforestation rates for selected countries from 2000 - 2005

Source: FAO

Tropical forest areas are recognized as an important sink for carbon dioxide (CO_2) or for carbon sequestration. This is the reason why many conservationists and scientists stress forest preservation as an essential requirement to reduce the impacts of climate change (Phat et al., 2004). Instead of clearing forest areas and converting land that is already used for agricultural crops (edible biomass), it is suggested that wastelands are utilised to produce biomass for energy production. Another suggestion is to focus on converting agricultural by-products or organic residues into biofuels. This type of scheme will reduce the need for more land, especially forest areas, to cleared.

4.1.2. Water

Over 70% of our Earth's surface is covered by water. However, about 97.5% of all water on Earth is salt water, with the remaining 2.5% as fresh water (Bouwer, 2000). For decades, the expanding world population, together with increasing agricultural activities, has already been placing pressure on freshwater supplies (Water Resources of Earth, 2000). It is believed that fresh water will be a critical limiting resource for many regions in the near future, especially Asia. As illustrated in Figure 4.4, agriculture is responsible for 87 % of the total water used globally.

About one-third of the world's population lives in countries that are experiencing water stress. Figure 4.5 shows the places that are facing water scarcity. It can be observed that a large area of Asia is affected, including East Asia and Southeast Asia. It has been predicted that unless sustainable water management is being practiced, most Asian countries will have severe water problems by the year 2020 (United States Filter Corporation, 1998; Postel et al., 1996).

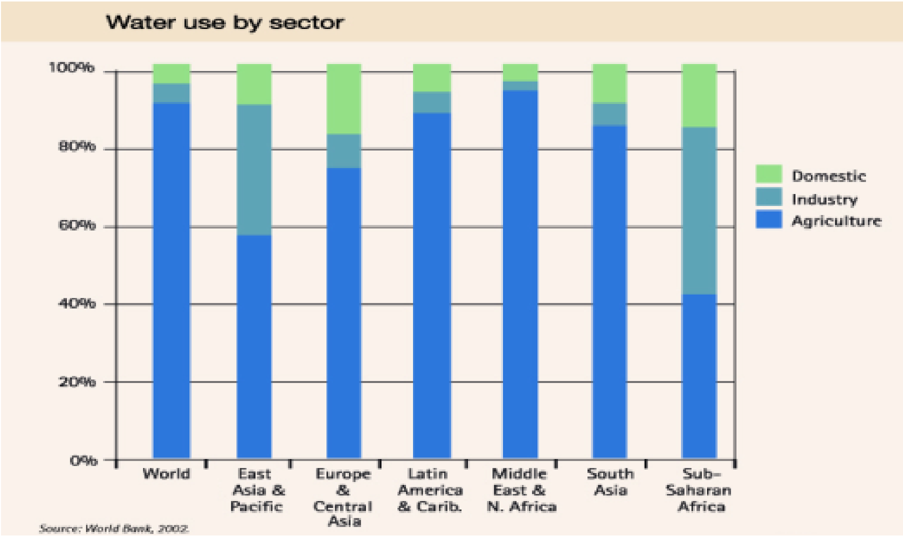


Fig. 4.4: A large portion of the world's water is consumed by agriculture

Source: Water Resources of Earth

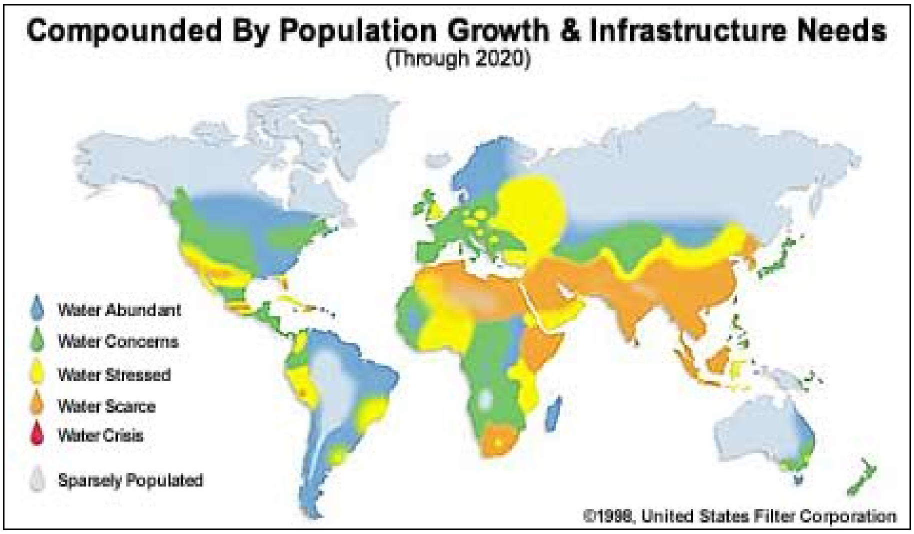


Fig. 4.5: Worldwide places that are facing water scarcity

Source: United States Filter Corporation

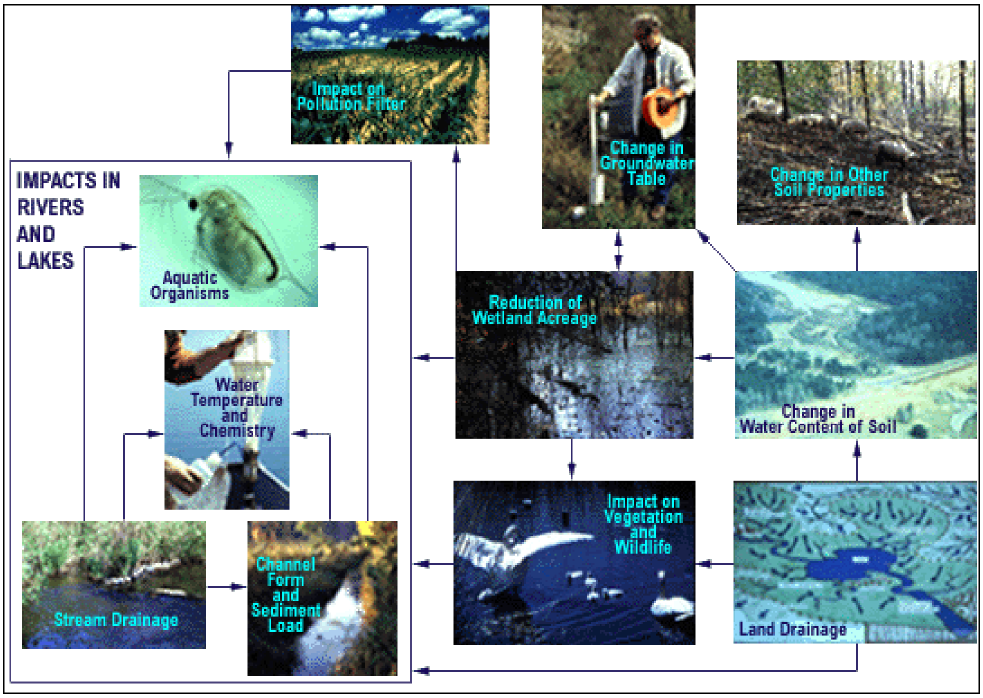


Fig. 4.6: The impacts of agricultural drainage to water, plants, wildlife and other ecosystem properties

Source: Institute of Water Research, Michigan State University

Agriculture's impact on water quality depends on the type of agricultural activity employed. Pollution or contamination of water occurs when pesticides or fertilizers are used. Apart from water loss, stress and waste, the mismanagement and contamination of water resources can lead to negative impacts on land and vegetation. Figure 4.6 illustrates the impacts of agricultural drainage to water, plants, wildlife, and other ecosystem properties (Mather, 1986). Effective and sustainable water management is essential for any agricultural systems, regardless of small or large-scale productions. Bouwer (2000) suggests that agricultural water management must be coordinated with, and integrated into, the overall water management of the region. Where water or rain starved regions are concerned, supplemental irrigation (SI) is encouraged to improve and optimize water availability. Another option lies in water harvesting (WH). In this method, improvements for agriculture can be made by directing and concentrating rainwater through runoff to plants (Oweis and Hachum, 2005).

4.1.3. Fertilizers and pesticides

Since the beginning of agriculture, humans have increasingly fixed atmospheric nitrogen as ammonia to be used as fertilizer. The fertilizers are necessary to create amino acids and carbohydrates in plants. There has been a growing concern that if used excessively, the quantity of mineral fertilizers in agriculture is having adverse effects on the environment. Attention has been drawn to the fact that when nutrients are applied to crops they are not all taken up by the plants immediately. There is also concern that some farmers might be applying inappropriate quantities of fertilizer. Depending on the sorts of nutrient and soil characteristics, different fertilizers are required to maintain certain soil quality levels.

It has reported that the rise in demand for palm oil has brought about the overuse of chemical fertilizers (Schäfer et al., 2007). The problem with the overuse of fertilizers and pesticides is that they may leak over time to the natural surrounding or ecosystem and cause pollution. The growing use of N fertilizers is also a concern. The part not taken up by crops (more than 50%) is either lost through leaching or released to the atmosphere as N gases including nitrous oxide a potent of greenhouse gas (GHG), (Vergé et al., 2007). Such losses may occur when nutrients:

- Run off land due to erosion caused by heavy rainfall

- Are leached through the soil to reach the groundwater
- Escape into the atmosphere as volatile gases.

In this area, ecologically based management programs can be implemented to reduce fertilizer and pesticide usage (usually 25-30%), without compromising on agriculture yield and quality. Therefore in both small and large scale agricultural and biomass production, this practice should be widely encouraged. The U.N. Food and Agriculture Organization (FAO, 2008) has encouraged that the standard procedures of Good Agricultural Practices (GAP) should be adopted for agriculture. However, education on such practices and the complete implementation of GAP may still be a challenge in most parts of developing countries. It has been proposed by UNESCO (United Nations Educational, Scientific and Cultural Organization) that governments work closely with farmers to promote education and to cultivate correct strategies to ease the adoption of GAP. According to FAO, there are at least seven core requirements of an effective GAP program. These include:

- Effective standards and regulations
- Strong government support
- Market demand
- Strong policy and co-operation
- Training and inspection
- Credible certification systems; and finally

- Clear GAP documentation.

4.1.4. Carbon dioxide emissions: what is carbon neutral and carbon footprints

For the next three decades, Asia is expected to be the largest source of GHG from agriculture, that is, about 50% of the total emissions (Vergé et al., 2007). Agriculture is a source of three primary greenhouse gases (GHGs): CO_2, methane (CH_4), and nitrous oxide (N_2O) (Johnson et al., 2007). Figure 4.7 shows the global anthropogenic greenhouse gas emissions broken down into 8 different sectors for the year 2000.

However, agriculture and plantations can also act as a sink for carbon via photosynthesis (Johnson et al., 2007). This process is known as carbon sequestration (Khoo and Tan, 2006a; 2006b). The concept of a 'CO_2 neutral' biomass system is founded on the belief that *all the carbon dioxide emissions generated from the combustion of biofuels is balanced off by the absorption CO_2 from the biomass via photosynthesis during its growth* (refer to Figure 4.8). This perception has received both sceptical and positive responses from researchers, scientists and environmental organizations worldwide (Aldred, 2008; U.K Royal Society, 2008). Some contend that the goal of having any biomass-biofuels that is entirely carbon neutral is a controversy or a misleading concept. Others claim that such perfect balance is difficult – or even impossible – to achieve (Schobert, 2002).

Practically, the carbon lost by converting rainforests, peatlands, savannas, or grasslands outweighs the carbon savings from biofuels. In a recent study, it was claimed by Fargione et al. (2008) that: "Converting rainforests, peatlands, savannas, or grasslands to produce food-based biofuels in Brazil, Southeast Asia, and the United States creates a 'biofuel carbon debt' by releasing 17 to 420 times more CO_2 than the annual GHG reductions these biofuels provide by displacing fossil fuels.". It is also argued that agricultural plantations certainly cannot absorb as much carbon dioxide as a matured forest occupying the same land area (Haverkort et al., 2007; Howden, 2007; Bohlin and Eriksson, 1996).

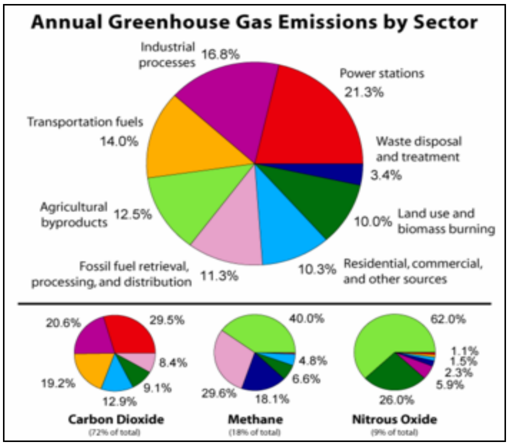


Fig. 4.7: Global anthropogenic greenhouse gas emissions for 8 different sectors for the year 2000

Source: United Nations Environment Program

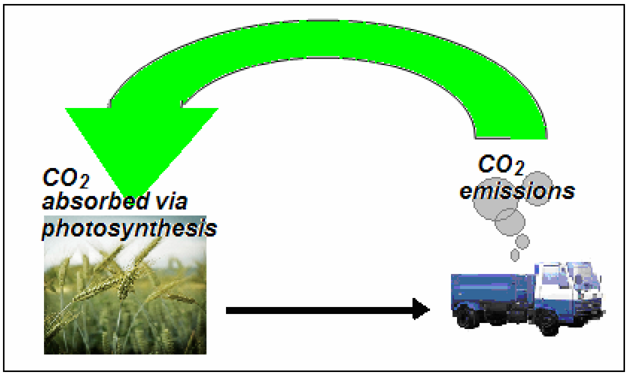


Fig. 4.8: 'CO_2-neutral' concept of biofuels is being subjected to debates

A simplified measurement rate has been proposed to shed some light surrounding the carbon neutral model. As long as “the harvesting rate of the biomass resources is not faster than the rate of growth/re-growth of the agricultural land producing it”, then the ‘zero-ing effect’ of CO_2 emissions-absorption can be possible. To promote the carbon neutral (or in some cases *carbon negative*) effect, both agriculture and land areas have to be managed in a sustainable manner so that adequate time is allowed for sufficient growth and photosynthesis to take place. Too often, large land use changes and tropical forest clearance to promote more growth of biomass ends up emitting more GHGs than can possibly be reduced. Efforts to enact harvest controls must be in place to ensure that no over-harvesting of resources that may cause lasting ecological damages, occur.

Proper farming practices such as sustainable forest management and rural development, organic farming, and effective employment of strategic land-use planning have been reported by Byrne et al. (2007), Pimentel et al. (2007), and Jarecki and Lal (2003). These practices encourage CO_2 sequestration, and hence ascertain that biomass production can control and reduce greenhouse emissions.

The entire life cycle of the GHG emissions – or carbon footprint – of biomass production from “field to fuel” should be considered to give the complete amount of the additional GHG released into the atmosphere due to fertilizers and energy inputs or land use change (deforestation), and measured against the amount being reduced (sequestered). This kind of analysis produces a more complete representation of the biomass-to-biofuel applications (Figure 4.9) as it takes into consideration the exact measures of GHG emissions produced from cultivating and harvesting the biomass feedstock, machinery operations, conversion of biomass into bio-fuels, and finally, the emissions generated from transportation (Baker et al., 2007; Blottnitz and Curran, 2007; Ravindranath et al., 2007).

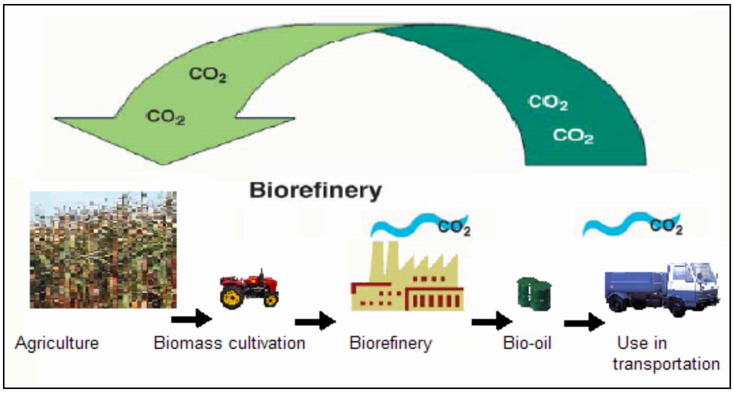


Figure 4.9 Life cycle carbon footprint gives a more complete account of the total CO_2 sequestered or emitted

4.1.5. Energy balance

All systems, including agriculture cultivation and biomass conversion, require some amount of energy expenditures or input. The crops or biomass feedstock for biofuels are harvested using machinery that burns fossil diesel. It is suggested that the analysis of the total energy consumption and generation is essential to determine if a biomass-to-bioenergy system is feasible (Khoo and Tan, 2006a; 2006b, Nguyen et al, 2007a; 2008, Prueksakorn et al, 2008,). Clearly, the benefits (measured as total energy output) of the whole system should be more than the resources or energy input. Large energy inputs for biomass cultivation and production does not only mean consuming resources and spending more money – it also means generating huge amounts of emissions, including greenhouse gases.

Indirect energy consumption may be associated with the production of machinery used in agriculture, and direct energy inputs can be the diesel and gas required for operating such machinery and tools. The fossil energy input into the biomass and biofuel production chain is a critical issue to consider. Figure 4.10 gives a basic flow diagram of the energy requirements of a biomass-to-biofuel system.

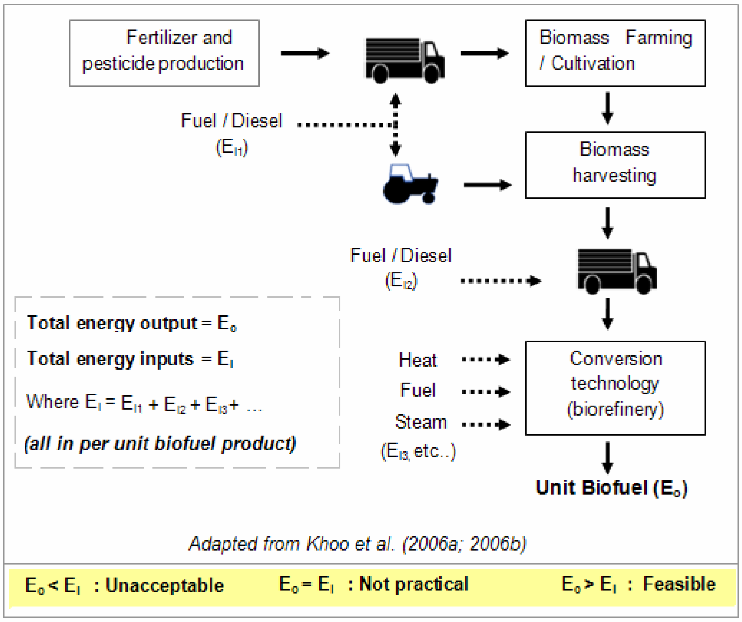


Figure 4.10: Energy balance calculations for biofuel production

The total energy output of the resultant biofuel product compared to the fossil energy inputs into its production are a sensible measure of the feasibility of any biomass-to-biofuel production scheme. In order to make the entire production system feasible or practical, the energy content of the biofuel ($\mathbf{E_o}$) should be greater than the accumulated energy inputs ($\mathbf{E_i}$) required –all measure in terms of *per unit biofuel product*. The larger the value of $\mathbf{E_o}$ (with respect to $\mathbf{E_i}$), the more favourable and sustainable the system. A few suggestions have been proposed to achieve this. Pimentel et al. (2005) and Shepherd et al. (2003) reported that the total energy consumption for organic agricultural systems can be substantially lower than intensive conventional agricultural systems. Apart from the biomass production system itself, an energy efficient biorefinery is essential to achieve the sustainability of the entire biofuel production chain (Blottnitz and Curran, 2007).

A holistic environmental management is recommended to analyze the feasibility of any biomass utilisation system along with the potential for carbon sequestration (Khoo and Tan, 2006a; 2006b; 2006c). This kind of holistic approach can be used to measure both energy and greenhouse gases for the entire series of production stages involved in biomass growth, cultivation, harvesting and final conversion at the bio-refinery (Nguyen et al, 2007b; 2007c).

4.2. Environmental tool: life cycle management

Interest in renewable energy systems are booming. However at this stage, a conservative approach is called for. Not all types of biomass utilisation strategies can result in environmental, or even, economical and social benefits (Cockcroft, 2008; Crenson, 2007). Various reports suggest a life cycle approach for looking into all the activities involved in biomass production and conversion (Khoo and Tan, 2006a; Mattsson et al., 2000).

Environmental management tools based on a life cycle approach are well accepted and used in scientific research. The complete environmental (and economical) results of biomass-to-biofuel systems can be demonstrated by carrying out a comprehensive study of the system's life cycle, from production of biomass in the field to transportation, conversion and use (Khoo et al., 2006a). In such an analysis, data and information related to environmental impacts – caused by air and water emissions and wastes – may be accompanied by energy and resource expenditures or costs. This type of analysis, also known as life cycle costing, has the advantage of showing the connection between proper environmental management and cost saving opportunities (Khoo et al., 2006b).

Figure 4.10 has been modified to Figure 4.11, where the emissions to both air and water, wastes (residues or by-products) of each activity have been considered. A complete life cycle investigation of the biomass-to-biofuel system ensures that all environmental concerns (e.g., GHGs, acidic and toxic emissions, wastewater, wastes or residues) have been properly accounted for. Basically, the more sustainable or "green" the system, the less impacts, as well as expenditures, it will incur (Khoo et al, 2006a; 2006b).

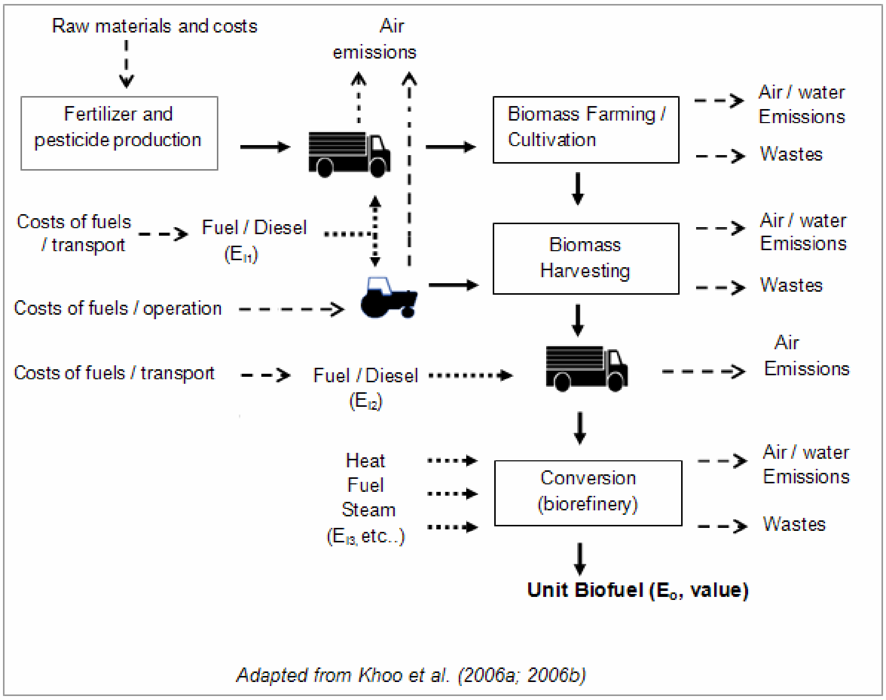


Figure 4.11: Life cycle management of biomass-to-biofuel to measure all associated energy/resource consumption, emissions and costs (optional)

The aim of such work is needed most of all to provide the information necessary – at a technical, administrative and managerial level – and to help policy makers in establishing the right policies and strategies (Khoo et al., 2006a; 2006b). Other excellent life cycle management of biomass utilisation can be found in reports provided by National Renewable Energy Laboratory (2008), Environment and Bioprocess Technology Centre (2008), Energy Research and Development Institute (2008), etc.

4.3. Overview of present environmental concerns

Energy needs will continue to grow despite the increase in oil prices. Clearly, fossil fuels cannot satisfy the world's appetite for energy in the long run, especially with the concern that these fuels are the main cause of climate change. Developing nations in East Asia have reached a consensus that proper strategies need to be put in place to make proper use of renewable energy sources.

A conservative approach to biomass utilisation is necessary to ensure the production of low or zero GHG biofuels, along with environmental protection. Not all biomass-to-biofuel systems are capable of producing results that will bring about social, economical and environmental benefits. Biofuels cannot be environmentally superior if their production results in ecological destruction, pollution and damage to society (Scharlemann and Laurance, 2008; Haverkort et al., 2007). Recent reports highlight that different biofuels vary enormously in how "green" they are, and that promoting the right type is crucial to ensure environmental sustainability (Deluca, 2006). Proper selection of biomass feedstock and the technology used should be carefully considered (Crenson, 2007; Kesavan and Swaminathan, 2007). Although not described in this chapter, novel technologies for converting biomass to biofuels are also important for extracting the optimal benefits from biomass resources. Moreover, it still remains a concern that large-scale cultivation of crops for biofuel will trigger new competition for available land. Moreover, if edible biomass (grains, food crops) is used for producing biofuels, increase in food prices will create yet another problem. These issues will be discussed in chapter 5 (social aspects of biomass utilisation).

Environmental damages will inevitably incur some sort of price to society in general – in the form of loss of resources, harmful health effects, additional expenditures or the costs of cleaning up. Most often, the price of environmental and ecological damages will be borne by future generations who have no say in the energy policy of today. In order to make biofuel contributions positive, attention must be given to a wide array of environmental issues. Some of the concerns highlighted are: deforestation, water scarcity, excessive usage of fertilizers and pesticides, and energy and carbon dioxide equilibrium. Careful steps are called for in order to move towards the goal of sustainable biomass utilisation, while solving or at least not adding to the problems already at hand.

Any negative environmental concerns should not discourage the use of biomass. East Asia has the potential to develop biofuel industries that are environmentally sustainable. In review, some of the suggestions given were:

- Application of GAP
- Water management (supplemental irrigation, water harvesting, etc)
- Investment in low or zero GHG biofuels by the adoption of sustainable land and forest planning to promote CO_2 sequestration by agricultural land
- Prevention of deforestation
- Organic farming
- Development of biorefinery technologies that optimally extract the greatest benefit from biomass resources
- Application of environmental tools such as life cycle management to provide the information necessary (at technical, administrative and managerial levels) to help policy makers in establishing the right policies and strategies.

As a whole, the use of biomass as a source of renewable energy can only be beneficial to society as a whole with proper (and ethical) decisions, strategies and policies in place. The importance of moving ahead cautiously is further stressed by the fact that agriculture is already providing food for 6 million people worldwide, and will have to feed up to 9 billion by the year 2050 (Deluca, 2006).

4.4. Environmental Prospect of Future biomass utilisation

Biomass plantations require land, water, fertiliser, pesticides, herbicides and energy. Some of the activities involved in the biomass-biofuel supply chain also involve the transportation of crops and the treatment of by-products. In the following sections, the environmental problems of future biomass plantation are described.

4.4.1. Future aspects of Land Use

Agricultural land occupied 5023 Mha (Mega-Hectares) in 2002. During the last four decades, agricultural land gained almost 500 Mha from other land uses. Every year during this period, and average 6 Mha of forestland and 7 Mha of the other land were converted to agriculture, and change occurring largely in the developing world. This trend is projected to continue into the future and it is projected that an additional 500 Mha will be converted to agriculture during 1997-2020 (Smith et al., 2007).

4.4.2. Future aspects of Water utilisation

The large consumption of water by agriculture calls for proper water planning and management. In some areas of China and India groundwater levels are falling by 1-3 metres per annum. The economic and environmental consequences are serious and will get worse in the absence of appropriate responses (FAO, 2003). Between 1995 and 2025 the areas affected by ‘severe water stress’ expand and intensify, growing globally from 36.4 to 38.6 million km^2. The increase is especially significant in Southern Africa, Western Africa and South Asia. The number of people living in these areas also grows from 2.1 to 4.0 billion people. In river basins under severe water stress conditions, strong competition for scarce water resources between household, industry and agriculture is anticipated. (Joseph et al., 2000).

4.4.3. Future aspects of fertiliser and pesticide utilisation

"FAO's fertilizer use projections to 2030" imply slower growth of nitrogen fertiliser use in most regions compare with the past (Table 4.1). Depending on progress in raising fertilizer use efficiency, the increase between 1997/99 and 2030 in total fertilizer use could be as low as 37 percent, entailing similar or even smaller increases in the direct and indirect N_2O emission from fertilizer and from nitrogen leaching and runoff. However, current nitrogen fertilizer use in many developing countries is very inefficient. In China, for example, which is the world's largest consumer of nitrogen fertilizer, it is not uncommon for half to be lost by volatilization and 5 to 10 percent by leaching. Hence, if the higher application rates projected for the future (Table 4.1) result in a disproportionately greater loss of N_2O, then it is likely that there will be a significantly greater global stress coming from nitrogen fertilizer. (Norse, 2003)

Table 4.1 Recent and Projected Fertilizer Use

Region	Nutrients (million tonnes)		Average kg/ha (arable land)	
	1997/99	2030	1997/99	2030
Sub-Saharan Africa	1.1	2.6	5	9
Latin America & Caribbean	11.3	16.3	56	67
Near East/North Africa	6.1	9.1	71	99
South Asia	21.3	28.9	103	134
South Asia excluding India	4.2	6.9	113	178
East Asia	45.0	63.0	194	266
East Asia excluding China	9.4	10.3	96	92
All above	84.8	119.9	89	111
Industrial countries	45.2	58.0	60	71
Transition countries	7.6	10.1	49	58
World	137.7	188.0	92	

Source: Bruinsma, 2003

Future pesticide consumption is likely to grow more rapidly in developing countries than in developed ones, although the introduction and spread of new pesticides may occur more rapidly in the latter. The environmental implications of this growth are difficult to assess. For example, application rates per hectare have gone down, but the new pesticides are biologically more active. Improved screening methods for pesticide safety and environmental health legislation have helped to reduce the mammalian toxicity of pesticides and to assess other potential environmental damage. On the other hand, the adoption of improved application techniques has not progressed sufficiently in the past decade, particularly in the case of sprayers, so that a high proportion of pesticide still fails to reach the target plant or organism. This situation is unlikely to change in the near future (FAO 2003).

4.4.4. Future aspects of Biodiversity

Managers of agricultural resources and plantations need to know how environmental and land change will affect biodiversity. Agriculture's main impacts on wild biodiversity fall into four groups. First, there is the loss of natural wildlife habitat caused by the expansion of agriculture. This has been a major force in the past, and will continue in the future, although much more slowly. FAO 2003 projects that an additional 120 million ha of arable land will be required over the next 30 years. Inevitably these will involve a reduction in the area of natural forests, wetlands and so on, with attendant loss of species.

Second, there is the general decline in species richness in managed forests, pastures and field margins, and the reduction of wild genetic resources related to domesticated crops and livestock. There are comprehensive and well-maintained ex situ germplasm stocks for the major crops, and gene transfer and other advanced plant breeding tools have opened up new possibilities for genetic improvement. Nevertheless, these losses in the wild could be serious for future crop and livestock breeding. They cannot be quantified at present, although advances in molecular biology may provide the tools needed for more robust monitoring.

Third, there is the reduction of wild species, including micro-organisms, which help to sustain food and agricultural production, for example through soil nutrient recycling, pest control and pollination of flowering crops. This can be regarded as damage to the life support system for agriculture, given the vital role some of these species play in soil fertility maintenance through nitrogen and carbon cycling. Such losses are of increasing importance with the shift to integrated farming and the growing emphasis on Integrated Rest Management (IPM). The intensive use of mineral fertilizers is known to change soil microbe populations (Paoletti, 1997), but does not appear to disrupt nutrient recycling. Intensive grazing lowers plant species richness in pastures but the long-term consequences of this are not known. In developed countries, loss of insect-eating bird species, as a result of reduction or removal of field margins or pesticide use, has been firmly linked with increases in crop pest damage. This problem may arise increasingly in developing countries.

Lastly, there is the reduction in wild species that depend for habitat, food, etc. on agriculture and the landscapes it maintains – the habitats, flora and fauna that would not exist without agriculture. Richly diverse chalk grasslands, for example, would revert to scrub or woodland without grazing pressures, with the loss of ground-nesting bird species, butterflies and herbaceous plants. The reduction of wild species is most apparent in those EU countries that have lost large areas of hedges, ditches, shrubs and trees through field and farm consolidation. Losses have also arisen from extensive use of insecticide and herbicide sprays with consequent spray drift on to field margins and other adjacent ecological niches. Increased stocking rates on extensive pastoral systems have led to a decline in birds that either nest on such land or are predators of rodents, etc. living on these lands (FAO 2003).

4.5. Potential Positive Environmental Aspect (future projections)

4.5.1. GHG Reduction

If sustainable land management and harvesting is implemented, biomass plantations can contribute to the mitigation of climate change by GHG reduction (carbon sequestration via photosynthesis). FAO projected that the likely biofuel use in

2050 is estimated to reduce annual CO_2 emission by 1.4 to 4.2 GtC, corresponding to a 5-25 percent reduction of fossil fuel emissions (FAO 2007). This positive estimation is based on the assumption that no large areas of forest are cleared for agriculture production, and no over-harvesting of biomass is carried out. This is because the clearing of raw land to produce biofuels actually contributes to global warming by emitting large amounts of greenhouse gases into the atmosphere (Writers, 2008).

4.5.2. Waste Reduction

Using waste biomass to produce energy can reduce the use of fossil fuels and reduce pollution and waste management problems. A recent publication by the European Union highlighted the potential for waste-derived bioenergy to contribute to the reduction of global warming. The report concluded that 19 million tons of oil equivalent is available from biomass by 2020, 46% from bio-wastes: municipal solid waste (MSW), agricultural residues, farm waste and other biodegradable waste streams (European Environment Agency, 2006; Marshall, 2007).

4.6. Concluding Remarks

Waste biomass utilisation is expected extensively and continuously in the future and contributes to the reduction of waste management problems. Well-designed and well-managed biomass plantations based on Life Cycle Management are essential and called for minimizing the consumption of water, fertilizers, pesticides, herbicides and for maximizing the productivity. Life Cycle CO_2 (or Carbon footprints) and energy balances are useful indicators to identify the effectiveness and productivity of the biomass utilisation from environmental points of view. However environmental problems of biomass utilisation come not only from GHG emission and energy consumption but also from deforestation, water consumption, fertilizer and herbicide consumption, and biodiversity decrease. The development of a set of tangible and user friendly integrated indicators for measuring the intensity of these environmental problems is imminent and important to minimize the total environmental impacts. Technology developments are also vital and it would allow us to make a remarkable progress in increasing productivity of biofuel or energy and to convert unused biomass into energy sources.

References

Associated Press (2007) : *U.N.: Not so fast with ethanol, other biofuels*, http://www.msnbc.msn.com/id/18551000/ (accessed : 18 Jan 08)

Aldred, J. (2008) : *Biofuels may not deliver car*Aldred, J. (2008) : *Biofuels may not deliver carbon cuts, scientists warned*, Monday Jan 14, Guardian: UK.

Baker, J.M., Ochsner, T.E., Venterea, R.T., Griffis, T.J. (2007) : Tillage and soil carbon sequestration – what do we really know?, *Agriculture, Ecosystems & Environment,* 118, 1–5.

Bala, G., Caldeira, K., Wickett, M., Phillips, T.J., Lobell, D.B., Delire, C., Mirin, A. (2007) : Combined climate and carbon-cycle effects of large-scale deforestation, *Proc Natl Acad Sci U.S.A*., Jun 5; 104(23), 9911.

Benhin, J.K. (2006) : Agriculture and deforestation in the tropics: a critical theoretical and empirical review, *Ambio.*, 35(1), 9 – 16.

BTG Biomass Technology Group (2007) : http://www.btgworld.com/ (accessed : 18 Jan 08)

Bonnie, R., Schwartzman, S., Oppenheimer, M., Bloomfield, J. (2000) : Counting on the cost of deforestation, *Science*, June, 288, 1763-1764.

Bohlin, F., Eriksson, L.O. (1996): Evaluation criteria for carbon dioxide mitigating projects in forestry and agriculture, *Energy Conversion and Management*, 37(6-8), 1223-1228.

Bouwer, H. (2000) : Integrated water management: emerging issues and challenges, *Agricultural Water Management*, 45, 217 – 228.

Blottnitz, H.V. and Curran, M.A. (2007): A review of assessments conducted on bio-ethanol as a transportation fuel from a net energy, greenhouse gas, and environmental life cycle perspective*, Journal of Cleaner Production*, 15, 607-619.

Byrne, K.A., Kiely, G., Leahy, P. (2007): Carbon sequestration determined using farm-scale carbon balance and eddy covariance, *Agriculture, Ecosystems & Environment*, 121, 357–364.

Cockcroft, P. (2008): *Asia's biodiesel plants sit idle as costs soar*, Business Times, Wednesday, Jan 16, pg. 13.

CBS News (2007) : U.N.: Biofuels Could Devastate Environment, ROME, May 8, 2007.

Channel News Asia (2007) : *Malaysian palm oil earnings to hit record in 2007*, Sunday, September 16.

Crenson, M. (2007): *Biofuels Boom Raises Tough Questions*, Associated Press.

Deluca, T.H. (2006): Looking and Biofuels and Bioenergy, *Science*, 312, June, 1743-1748.

Environment and Bioprocess Technology Center (2008) : *Life Cycle Inventory Study for Biomass Derived Fuel*, SIRIM Berhad, Shah Alam, Malaysia.

Energy Research and Development Institute (2008) : *Analysis and Proposal for Effective Use of Biomass in Northern Thailand*, LCM Center, Chiang Mai University, Thailand.

Euractive (2008): *Can Biofuels Cure Europe's Oil Dependency?,* http://www.euractiv.com/en/HomePage (accessed : 18 Jan 08)

European Environment Agency (2006) : *How much bioenergy can Europe produce without harming the environment?*, EEA Report no. 7.

FAO (Food and Agriculture Organization) (2008): www.fao.org/ (accessed: 18 Jan 08)

FAO (2003) : FAO corporate document repository 2003, *World Agriculture: Towards2015/2030*.

Fargione, J., Hill, J., Tilman, D., Polasky, S. Hawthorne, P. (2008): Land Clearing and the Biofuel Carbon Debt, Sciencexpress, 7 February 2008, 1-4.

Haverkort, A.J., Bindraban, P.S., Bos, H. (2007): Food, fuel or forest?: opportunities, threats and knowledge gaps of feedstock production for bio-energy, *Proceedings of Wageningen Seminar on Bio-energy*, March 2, Wageningen: the Netherlands.

Howden, D. (2007): *Deforestation: The hidden cause of global warming*, The Independent, May 14.

International Herald Tribune (2007): *The biofuel myths*, July 10, 2007.

Institute of Water Research (2004), Michigan State University, http://www.iwr.msu.edu/ (accesed : 24 Jan 2008)

Jarecki, M., Lal, R. (2003) : Crop management for soil carbon sequestration, *Critic.Rev. Plant Sci.,* 22, 471–502.

Johnson, J.M.F., Franzluebbers, A.J., Weyers, S.L., Reicosky, D.C. (2007): Agricultural opportunities to mitigate greenhouse gas emissions**,** *Environmental Pollution*, 150(1), 107-124.

Joseph, A., Tomas, H., Tomas, R. (2000): *World Water in 2025*, Center for Environmental Systems Research, University of Kassel

Kesavan, P.C., Swaminathan, M.S. (2007): Strategies and models for agricultural sustainability in developing Asian countries, *Philos Trans R Soc Lond B Biol Sci.,* Aug 30.

Khoo, H.H., Tan, R.B.H. (2006a): *Proposed bio-conversion technologies for food waste recycling in Singapore*, 5th AIST Workshop on LCA for Asia Pacific Region, 14-16 Nov, Tsukuba, Japan.

Khoo, H.H., Tan, R.B.H. (2006b) : Environmental Impact Evaluation of Conventional Fossil Fuel Production (Oil and Natural Gas) and Enhanced Resource Recovery with Potential CO_2 Sequestration, *Energy and Fuels*, 20, 1914-1924.

Khoo, H.H., Tan, R.B.H. (2006c): Life Cycle Investigation of CO_2 Recovery and Sequestration, *Environmental Science and Technology*, 40(12), 4016-4024.

Khoo, H.H., Tan, R.B.H, Salim, S., Wu, Y.M. (2006a) : *Life Cycle evaluation and economic considerations of the pyrolysis-gasification of municipal solid waste in Singapore*, In: K. Aravossis, C.A. Brebbia, E. Kakaras & A.G. Kungolos (Eds.), "Environmental Economics and Investment Assessment", WIT Press, Southampton, UK, 43 – 54.

Khoo, H. H., Spedding, T. A., Bainbridge, I., Taplin, D. (2006b): *Creating a Green Supply Chain,* In: J. Sarkis (Ed.), “Greening the Supply Chain”, Springer, London, UK, 341 – 361.

Mather, A.S. (1986): *Land Use and Environment*, In: “Land Use”, Longman, New York.

Mattsson, B., Cederberg, C., Blix, L. (2000): Agricultural land use in life cycle assessment: case studies of three vegetable oil crops, *Journal of Cleaner Production*, 8, 283 – 292.

Marshall, A. T. (2007): *Bioenergy from Waste: A Growing Source of Power*, Waste Management World Magazine, April, p34-37.

National Renewable Energy Labouratory (2008): *Recent Reports on Biomass Conversion Process Engineering and Life-Cycle Analysis*, U.S. Department of Energy, http://www.eere.energy.gov/ (accessed: 18 Jan 08)

Norse, D. (2003): *Fertilizers and World Food Demand-Implications for Environment Stresses*, IFA-FAO Agriculture Conference 2003.

Nguyen, T. L. T., Gheewala, S. H., Garivait, S., (2007a): *Full chain energy analysis of fuel ethanol from cassava in Thailand*, Environmental Science and Technology, 41, 4135-4142.

Nguyen T.L.T., Gheewala, S.H., Garivait, S. (2007b): *Fossil energy savings and GHG mitigation potentials of ethanol as a gasoline substitute in Thailand*, Energy Policy Vol. 35, No. 10, pp. 5195-5205.

Nguyen T.L.T., Gheewala, S.H., Garivait, S. (2007c): *Energy balance and GHG-abatement cost of cassava utilisation for fuel ethanol in Thailand*, Energy Policy, Vol. 35, No. 9, pp. 4585-4596.

Nguyen, T. L. T., Gheewala, S. H., Garivait, S.(2008): *Full chain energy analysis of fuel ethanol from cane molasses in Thailand*, Applied Energy (in press)

Oweis, T., Hachum, A. (2006) : Water harvesting and supplemental irrigation for improved water productivity of dry farming systems in West Asia and North Africa, *Agri. Water Manage.*, 80, 57 – 73.

Prueksakorn, K., Gheewala, S.H. (2008): *Full chain energy analysis of biodiesel from Jatropha curcas L. in Thailand*, Environmental Science and Technology (in press)

Ravindranath, N.H., Balachandra, P., Dasappa, S., Usha Rao, K. (2006): Bioenergy technologies for carbon abatement, *Biomass and Bioenergy*, 30(10), 826-837.

Postel, S.L., Daily, G.C., Ehrlich, P.R. (1996): Human appropriation of renewable fresh water, *Science*, 271(5250), 785-788.

Pimentel, D., Hepperly, P., Hanson, J., Douds, D., Seidel, R. (2005): Environmental, energetic, and economic comparisons of organic and conventional farming systems, *BioScience*, 55, 573–582.

Phat, N.K., Knorr, W., Kim, S. (2004): Appropriate measures for conservation of terrestrial carbon stocks - Analysis of trends of forest management in Southeast Asia, *Forest Ecol. Manage.,* 191(1-3), 283-299.

Schäfer, R.B., Caquet, T., Siimes, K., Mueller, R, Lagadic, L., Liess, M. (2007): Effects of pesticides on community structure and ecosystem functions in agricultural streams of three biogeographical regions in Europe, *Science of the total environment*, 382, 272-285.

Scharlemann, J.P.W., Laurance, W.F. (2008): How Green Are Biofuels ?, *Science*, 319, 52-53.

Schobert, H.H. (2002): *Energy and Society: An Introduction*, Taylor and Francis, London, U.K.

Shepherd, M., Pearce, B., Cormack, B., Philipps, L., Cuttle, S., Bhogal, A., Costigan P., Unwin, R. (2003): *An Assessment of the Environmental Impacts of Organic Farming*, Defra, UK, pp. 80.

Smith, P., D. Martino, Z. Cai, D. Gwary, H. Janzen, P. Kumar, B. McCarl, S. Ogle, F. O'Mara, C. Rice, B. Scholes, O. Sirotenko (2007): Agriculture. In *Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Sudha, P., Ravindranath, N.H. (1999): Land availability and biomass production potential in India, *Biomass & Bioenergy*, 16(3), 207-221.

U.K Royal Society (2008): *UK scientists say biofuels may not cut* CO_2, Jan 15, UK Royal Society.

United Nations Environment Program (2007): *Tree-Nation*, http://www.unep.org/billiontreecampaign/ (accessed: 18 Jan 08)

United States Filter Corporation (1998): *World: Places that are facing water scarcity*, Sturbridge, Massachusetts (MA), 01566, US.

Vergé, X.P.C., De Kimpe, C. and Desjardins, R.L. (2007): Agricultural production, greenhouse gas emissions and mitigation potential, *Agricultural and Forest Meteorology*, 142(2-4), 255-269.

Water Resources of Earth (2000): *Portion of water consumed by Agriculture*, University of Michigan, U.S.

Writers, S. (2008): *Converting land for biofuel worsens global warming: study, Energy Technology,* Washington (AFP) Feb 7, 2008.

CHAPTER 5

SOCIAL ASPECTS OF BIOMASS UTILISATION

5.1. Introduction

This chapter focuses on various social issues related to accelerated production and consumption of bioenergy in East Asia. The findings on social aspects are based on a case study of India, giving details on demand and supply of bioenergy, its merits in terms of rural employment generation and rise in income, and possible negative impacts of food insecurity and increased pressure on natural resources.

The demand for transport fuels is continuously rising and increased use of fossil fuels is constrained due to international commitments, environmental concerns and financial considerations. These factors have attracted the global attention towards development of non-conventional or renewable energy forms including bioenergy. Figure 5.1 depicts the energy mix for some major regions of the world and indicates that the share of thermal energy dominates in total energy production. Further, the share of renewable energy and bioenergy in total energy production is quite low. For instance, in USA the share of bioenergy is 1.1% and in Japan it is 1.07 %, in comparison to India's about 3%. Thus, there is enough scope for development of bioenergy, particularly in East Asian countries, which have suitable conditions for biomass production (Sharma, 2000; Planning Commission, 2003; WEO, 2006; PFI, 2007).

Consumption of bioenergy varies in both forms and proportions in various countries. For example, Brazil uses ethanol as 100% fuel in about 20% of vehicles and

25% blend with gasoline in the rest of the vehicles. USA uses 10% ethanol-gasoline blend whereas it is 5% in Sweden and 10% in Australia. India has mandated 5% ethanol blend, which will increase to 10% by October, 2008 with long-term targets set at 20% blending for both biodiesel and bioethanol. In most of the East Asian countries biofuel policies have emerged almost at the same time, in last 2-5 years, and are dedicated to promotion of biofuels (Raju, 2006; PFI, 2007).

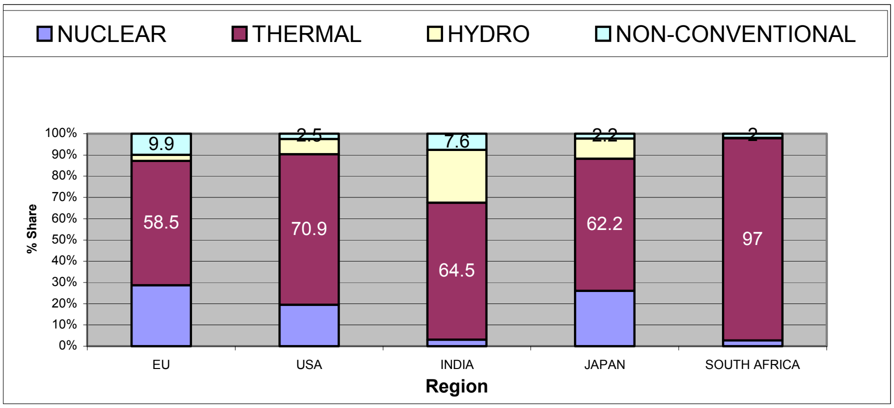


Figure 5.1: Percentage fuel-mix in power production in some regions (2004)

Source: Sharma (2000); Planning Commission (2003); WEO (2006); PFI (2007)

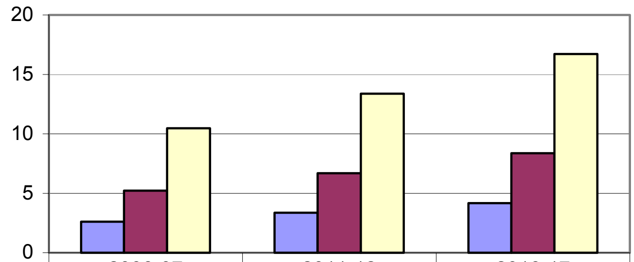
5.2. Promotion of Bioenergy

Most East Asian countries have extensive programmes on biomass energy with emphasis on production of biodiesel and bioethanol production. In some countries, like India, thermal gasification and anaerobic decomposition of biomass are also being promoted. Development and use of biofuels by East Asian economies has been initiated with the launch of national biofuel policies. Various types of biomass are used for the production of biofuels and blending targets range from 5% to 20%, in most countries.

5.2.1. Future demand projections

The future of bioenergy in East Asian countries seems to be bright due to gap in demand and supply of biofuels, which is to be met either by import or by producing bio-fuel within the country. For example, in India, renewable energy scenario indicates that the share of bioenergy in total renewable energy will be as high as 50% by 2032. Figure 5.2 show the demand for biodiesel and area requirement for energy plantation for various levels of blending in India. The National Biodiesel Mission of the GoI aims at introducing a mandatory 5% blend of biodiesel in 2006-07 and gradually increasing it to 20% by 2011-12. To achieve this, through domestic production, the government hopes to bring about 2.19 million hectares land under Jatropha plantation in 2006-07 and raise it to 11.2 million hectares by 2011-12. Tax incentives and guaranteed minimum purchase prices by the state oil companies for all biodiesel products are being considered. The Ministry of Petroleum and Natural Gas has launched a bio diesel procurement policy with effect from January 01, 2006 at the rate Rs.25 per litre, which has been increased to Rs.26.5 per litre recently, through state owned petroleum companies in 12 states (IBFC, 2008; MNRE, 2007).

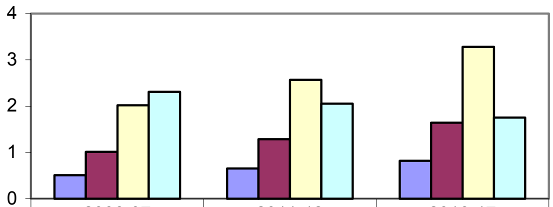
In case of ethanol, a 5%t blend in petrol has been made mandatory, which will increase to 10% by October, 2008. Figure 5.3 projects the future ethanol demand and indicates that, under normal conditions, available supply of ethanol would be sufficient upto 10% blending requirement even upto 2016-17. However, due to an expected large increase in vehicle population and for blending of 10% and above, the demand for ethanol will increase, which can be met either by increasing area under sugarcane or by application of other production techniques using cellulosic crops.



	2006-07	2011-12	2016-17
5% level	2.62	3.35	4.18
10% level	5.23	6.69	8.36
20% level	10.46	13.38	16.72

Data Source: Committee on Biofuels, GOI; Note: Area calculated on the basis of plantation density of 2500 per hectare, seed production of 1.5 kg per tree or of 3.75 T of seed per hectare corresponding to 1.2 T of oil per hectare of plantation.

Figure 5.2: Present and future biodiesel demand (MT)



	2006-07	2011-12	2016-17
demand 5% level	0.51	0.65	0.82
demand 10% level	1.01	1.29	1.64
demand 20% level	2.02	2.57	3.28
supply	2.31	2.05	1.75

Date Source: Planning Commission (2003)

Figure 5.3: Present and future ethanol demand (MT)

5.3. State of social development

Despite rapid economic growth, domestic income distribution is skewed in many East Asian countries and the poor are being bypassed by this growth. At an aggregate level, in Asia, the share of income of the poorest 25 percent of the population fell from 7.3 percent in 1990 to 4.5 percent in 2004 (ADB, 2007). In case of India, although the economy has grown steadily over the last two decades, its growth has been uneven when comparing different social groups, economic groups, geographic regions, and rural and urban areas. After economic reforms in earlier 1990s, it has been observed that even though the country is growing richer, a large part of population is only growing hungrier as the much needed calories have vanished from the plates of those who need them the most (HT, 2008).

5.3.1. Low human development

Human development Index (HDI), is a composite measure of three dimensions of human development, namely, living a long healthy life (measured by life expectancy), being educated (measured by adult education and enrolment at primary, secondary and tertiary levels) and having a decent standard of living (measured by purchasing power parity). The HDI values and ranking based on it for the countries participating in this study, (out of a total of 177 countries reported in HDR-2007-08), are – Japan- 0.953 (8), Singapore- 0.922 (25), Malaysia- 0.811 (63), Thailand- 0.781 (78), Philippines-0.771 (90) and India- 0.619 (128).

Thus, the current situation of social development in some East Asian countries, like India, is quite disturbing. While India is being seen as one of the fastest growing economies of the world, shining with 8-9% annual economic growth, the ground reality on social development front is quite different. An incredibly low HDI of 0.619 in 2005, ranks India at 128th place in the list of 177 countries, which is two places lower than the country's ranking in 2006. This rank was 127/177 in 2003 and 126/177 in 2004, and thus, India has slipped two places between 2004 and 2005. Further, India ranked 128th even in 2000, which is certainly a matter of great concern (HDR, 2007-08). The ranks in others social parameters are- life expectancy at birth 125 (63.7 years); Adult literacy ratio 114 (61.0%); combined entry in primary, secondary and tertiary level 122 (61.0%); and GDP per capita income is US$3452, which all indicate a low level of human development in India. In comparison, its two main neighbours China and Sri Lanka have quite impressive HDI rankings of 0.777 (81) and 0.743 (99), respectively. Despite a fast rate of growth of the GDP, on the basis of the HDI, India is ranked in the lowest bracket of 50 countries along with African countries. Thus, GDP growth can be a determinant of social development only if it is shared equitably by all sections of the people (HDR, 2007-08).

5.3.2. Large income disparity

Wealth distribution in East Asia's developing economies is quite uneven. For example, in India, the top 10% of people earn more than 33% of the income. While India has produced more millionaires and billionaires, in terms of dollar, compared with most other developing countries, a quarter of the nation's population earns less than the government-specified poverty threshold of US$0.40 per day. A survey of 250 MNCs in 47 countries indicates that the salary hikes in India has been among the top 10 countries, globally, and highest in Asia, which is benefiting middle and upper middle class people only. But India cannot derive much satisfaction from the GDP growth when more than a quarter of the population in the country still lives in abject poverty. Several studies, indicate that a variety of social and economic inequalities have a strong impact on population's social development indicators such as health, nutrition, female literacy and gender equality (HDR, 2007; Asianage, 2007; HT, January 18, 2008).

5.3.3. Declining calorie intake

The latest World Development Report stresses that in the 21st century, agriculture continues to be a fundamental instrument for sustainable development and poverty reduction. Three of every four poor people in developing countries live in rural areas (2.1 billion living on less than US$2 a day and 880 million on less than US$1 a day) and most of them depend on agriculture for their livelihoods. Given, their location and skills, promoting agriculture is imperative for meeting the Millennium Development Goal of halving poverty and hunger by 2015 and reducing the same thereafter. As per Global Hunger Index published by the International Food Policy Research Institute, the proportion of calorie-deficient people in India at present is more than what is was in late 1980s. In a recent survey, conducted by the National Nutrition Monitoring Board, it is revealed that compared with 1990, Indians today are consuming almost 16% less calories per day. On an average, Indians in 2005 consumed 370 kcal less per day than they did in 1988. Similarly, in last seven years, a period of economic boom, number of children under 5 years of age who are malnourished has dropped by just 1% (47% to 46%), as reported by the National Family Health Survey (WDR, 2008; HT, 2008).

5.3.4 Gender inequality

Gender inequality exists in every country, but it varies in degree. As per the Human Development Report of 2008, the three top ranking countries in the gender-related development index (GDI) are Iceland, Norway, and Australia and Iceland tops with the GDI value of 0.962 in the list of 177 countries. A GDI value of 1.00 indicates a maximum achievement in basic capabilities without any gender bias. The GDI values for East Asian countries covered in this study are- Japan (0.942); Singapore (Not Available); Malaysia (0.802), Thailand (0.779); Philippines (0.768) and India (0.600). Thus, some countries in East Asia show low level of gender equality. For example, India ranks 126 in the list of 177 countries with a GDI value of 0.600, showing that women in the country suffer the double deprivation of gender disparity and low achievement (HDR, 2008). Gender inequality often results in the inequality in child care, nutrition and education, which leads to higher morbidity and mortality among female children.

5.4. Social impacts of bioenergy

From the present plans of governments in East Asian countries, it is foreseeable that large amount of land, water and man-power resources will be devoted to bioenergy programs, which may have irreversible socio-economic and environmental impacts. If selected judiciously and managed properly, accelerated development and use of bioenergy may accrue several benefits to the society. Some positive and negative social impacts of bioenergy development are outlined as follows.

5.4.1. Positive impacts

Some East Asian countries like India, have a large land area classified as wastelands and degraded forests, which could be utilised for growing biomass. This would offer an opportunity to develop a vast extent of wastelands, leading to more vegetative cover and protect such lands from further degradation. Increased used of biofuels will reduce import of petroleum products improving the economy and reduce dependency on imported oil resulting in energy security for these country. Use of biodiesel and bioethanol blending, even at current levels of 5-10%, will substantially reduce auto emissions and will create a positive impact on air quality, particularly in urban areas. Reduction in emissions of CO_2 and SO_2 will be an added advantage from global perspectives and CDM opportunities.

Increased employment in farm-activities of bioenergy development such as raising of biofuel crops, seed collection, briquetting and transportation of biomass, etc. would employ many people and help in raising the economic status of people in rural areas. Increased income may reduce income disparity between the rich and poor in rural area and also between rural and urban areas. Higher income levels are positively correlated with rise in literacy rates, medical care and nutrition. Traditional use of biomass as domestic fuel for cooking, heating and other purposes causes several health hazards among women and children in rural areas and urban poor areas. Introduction of biopower, biogas and other clean fuels will drastically reduce such health problems resulting in increased life expectancy and decreased infant mortality in East Asia.

5.4.2. Negative Impacts

Ongoing global debate on "biofuels versus food security" could be more relevant for East Asian countries. At global level, vegetable oil production in 2006 has been 153 MT, which was short of the demand by about 10 MT. In 2007, while crude oil prices rose by 40%, oil palm prices rose by 67%, which translates into crude at US$593 per tone and palm oil US$735 per ton. Rising prices of cooking oil are forcing poor residents in India to ration every drop. In the US, bakeries are fretting over higher shortening cost and in Malaysia, brand new factories built to convert vegetable oil into diesel for trucks sit idle as their owners are unable to afford the raw material- i.e. edible oil. Thus, from India to Indiana, shortage and soaring prices for palm oil, soybean oil and other vegetable oils are examples of global costly food. (HT, January 19, 2008).

WDR (2008) indicates that potential conflict between food and fuels is bound to increase in future and cereal production has to rise by 50% by 2030 to meet the escalating worldwide demand. The competition between food and fuel can be estimated with the fact that "grain required to fill than tank of a sports utility vehicle once could feed one person for a year." In 2006-07, around 20% of maize harvest was used for ethanol but it could displace only 3% of gasoline consumption. GHG emission reduction due to biofuels is also vary substantially. For example, while Brazil's sugarcane based ethanol programs estimate a cut of about 90%, it is only 10-30% from USA's maize-derived ethanol (WDR, 2008).

As estimated by the International Water Management Institute (IWMI), present plans of India and China for biofuel production could face acute water scarcity by 2030. Both India and China are two water-scarce countries as they use more than 75% of its available fresh water for human consumption against the global norms of below 60%. If both of these countries pursue their present biofuel plans, they will definitely be in the red zone in water terms.

The participation of small and marginal farmers in the biofuel projects is uncertain due to many reasons. In case of biodiesel, the initial instability in the market demand for raw material and return from investments may not be quick and attractive due to long gestation period. Involvement in ethanol requires accessibility to irrigated land, which small farmers may not be able to spare due to their needs of other crops. Further, initial investments in both biodiesel and ethanol programmes are large, which such farmers may not be able to afford.

Changes in crop pattern, such as shifting from food crops to commercial crops (sugarcane or oil-seed crops) may create employment problems for small farmers and landless labourers. Present cultivation practices offer them round the year farm-employment but commercial energy crops may keep them out of work for a part of the year. In general, biomass energy systems appear to be more labour intensive than their fossil fuel counter parts. But the distribution of these jobs among various stages of biofuel production process is very important. If the biomass handling and transport is a major factor then the rural job opportunities will be promoted. On the contrary, the distribution of waste, marginal and pasture lands to corporate and bigger farmers will have adverse effect on the rural poor community as it could lead to highly mechanized production process and less job opportunities.

5.5. Assessment of social benefits

As mentioned earlier, biomass energy, offers several socio-economic and environmental advantages. Assessment of social benefits of bioenergy development is explained with the help of some Indian case studies as follows.

5.5.1. Employment generation

(1) Thermal gasification power plant at Sunderbans, West Bengal

Chhottomollakhali Island in Sunderbans is situated in the district of South 24 Parganas, about 130 km away from Kolkata, having a population of about 28,000. It is difficult to extend grid electricity to this Island due to prohibitive cost involved in crossing of various rivers and creeks. In the absence of electricity, the economic activities of the Island were suffering and people had a very hard life. Installation of biomass based Gasifier Power Plant (4x125 kW) in June, 2001 has changed the life of the inhabitants of four villages on this remote Island. The plant is catering to electricity needs of domestic, commercial and industrial users such as drinking water, hospital, ice factory, etc. Employment generated due to energy plantation, used in the biopower plants, is about 100 person days per hectare.

(2) Earth stove by Nishant Bioenergy

This is a community cooking stove, named as Sanjha Chulha (means combined stove), also known as "Earth Stove," developed by Nishant Bioenergy and uses agro-waste briquettes as fuel. Many schools and other institutions in India, provide meals for a large number of people and, use Liquefied Petroleum Gas (LPG) for cooking, which is currently subsidised by the Government. However, this subsidy is due to be phased out over the next five years and the cost of cooking by LPG is set to increase. Use of such type of community biomass stoves would save lot of funds for these institutions as waste briquettes are much heaper than LPG. It will allow use of a sustainable fuel (agro-waste), provide the briquetting industry with a more regular income, and generate income for the small farmers and labourers who will be involved in the supply chain. Estimated social benefits of an Earth Stove for 450 persons are as follows.

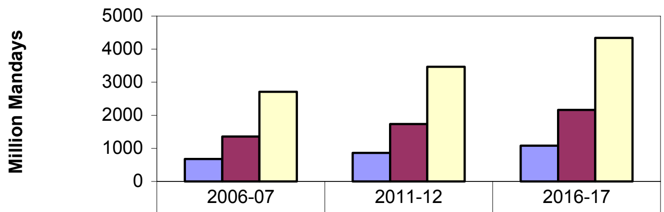
- Briquetting plants earn typically 40% more from selling briquettes to schools and similar community kitchens than to industrial users, and have a guaranteed market.
- Production of one tonne of briquettes needs about one day of labour, which is used by six stoves and thus generates one extra full-time job.
- Farmers are paid about Rs.500 per tonne for agriculture waste, and a typical small holding of 2 hectares produces about 5 tonnes of waste per year, which brings in the equivalent of an extra month's income (Rs.2500) to the farmer.
- The government has encouraged users by providing 100% depreciation on the capital cost of the stove.

(3) Biodiesel production

Under the bio diesel programmes, employment will be generated in preparation of land and plantation, nurseries development, seed collection, oil extraction centres, transesterification plants, blending and marketing, etc. Of this, the plantation and seed collection are labour intensive and the most dominant item of the expenditure generating job opportunities in rural areas. Some of the estimates of employment created by value added chain of biodiesel are as follows (Planning Commission, 2003).

- One hectare of plantation will generate employment of 311 person days.
- About 40 person days of labour per hectare is needed for seed collections.
- Additional employment in value added chain.

Based upon the above premises, Figure 5.4 indicates a large potential for rural employment in the farm sector. In addition, millions of jobs will be created in non-farm activities such as oil extraction plants, biodiesel production units and associated activities. The income derived from plantation and seed collection will be additional and may help in reducing poverty (Planning Commission, 2003; UNCTAD, 2006).



	2006-07	2011-12	2016-17
at 5% level	679	868	1083
at 10% level	1355	1734	2167
at 20% level	2711	3468	4333

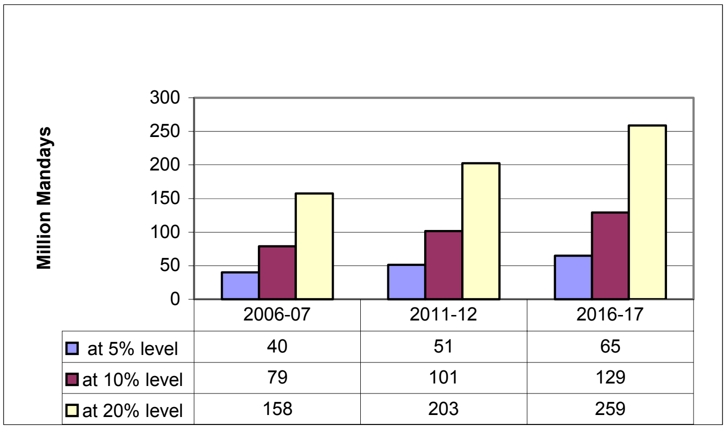
Source: Author's Estimates based on Data from Planning Commission and other GoI Sources.

Figure 5.4: Employment in biodiesel production at various blending levels

4) Bioethanol production

In India, more than 50 million farmers and their families and about 0.5 million workers are dependent on sugarcane production for their livelihood. The sugar industry caters to an estimated 12% of rural population in nine sugar producing states through direct and indirect employment. Effectively, each farmer contributes to the production of 2.9 tone of sugar every year. The current distillery capacity is 2,900 million litres of alcohol, of which 1,300 million litres are attached to the sugar industry. Given the adequate availability of molasses and viable economic returns, present distillery capacity could meet E5 and possibly E10 demands (Planning Commission, 2003; KPMG., 2007).

But due to increase in petrol demand for an expected large increase in vehicle population and other economic activities or for achieving above 10% blending, additional acreage under cane will be required. Assuming 183 person days per hectare, with expansion of sugarcane acreage only, some estimates of employment generation, for various ethanol blending percentages, at all India level, are shown in Figure 5.5. In addition, millions of jobs will be created in ethanol production units and associated activities.



	2006-07	2011-12	2016-17
at 5% level	40	51	65
at 10% level	79	101	129
at 20% level	158	203	259

Source: Author's Estimates based on Data from Planning Commission and other GoI Sources.

Figure 5.5: Employment in ethanol production at various blending levels

5.5.2. Health Benefits

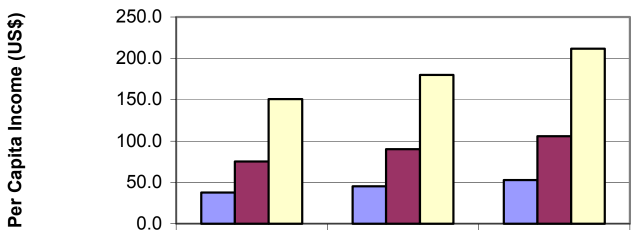
In developing countries, the most important indoor air pollutants are the combustion products of unprocessed solid biomass fuels used by the poor urban and rural people for cooking and heating. A recent report of the World Health Organization (WHO) asserts the rule of 1000, which states that a pollutant released indoors is one thousand times more likely to reach people's lung than a pollutant released outdoors, indicating the danger of indoor air pollutants. In India, about 90% of rural households still rely on biomass fuels such as wood, dung and crop residue for cooking and heating. The country has among the largest burden of disease due to the use of such fuels and 28% of all deaths due to indoor air pollution in developing countries occur in India. Cataract and adverse pregnancy outcome are the other conditions associated with the use of biomass fuels. In most of the cases, women and children are over-exposed to indoor air pollution as women spend 3-7 hours in the kitchen. Each day breathing in smoke is equivalent to consuming two packs of cigarettes and causes acute and chronic respiratory and cardiovascular diseases. Thus, the use of improved biomass techniques for cooking and home heating will improve quality of life for women and infants. Reduced incidences of diseases will also result in economic benefits due to less hospitalisation and work-days lost and less expenditure on medical care.

5.5.3. Women Empowerment

Development of bioenergy has the potential for engaging women in raising nurseries and collection of seeds, which could lead to their enhanced participation in the village economy. In India, bioenergy is included under the women development associate scheme initiated by the Indian Renewable Energy Development Agency (IREDA), which has undertaken extensive programme for the empowerment of women. The basic objectives of this scheme are to provide term loan by extending concession in its lending terms to women entrepreneurs and to generate entrepreneurial potential among women. In addition to term loan on soft terms, various concessions are provided to women entrepreneurs for setting up projects in bioenergy sector. Some of these concessions include waiver for registration and various other fees, rebate on interest rates and contribution of entrepreneurs, etc., which are in addition to the already existing concessions of central governments to all other entrepreneurs.

5.5.4. Possible Improvement in HDI

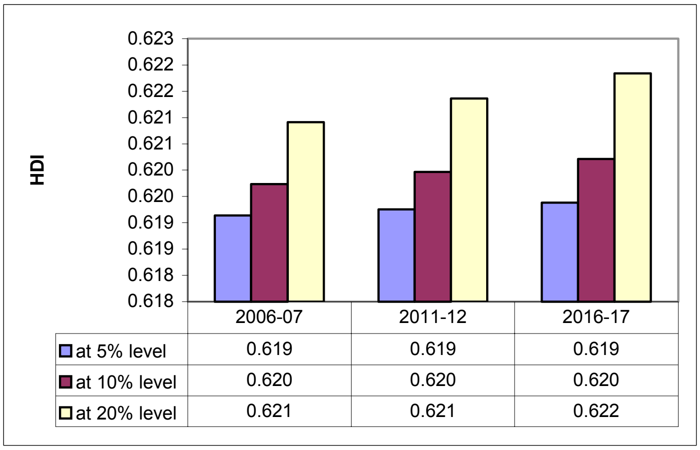
As indicated earlier, development of bioenergy programmes are expected to increase employment, which will improve income of individuals. People may use extra income to spend on their basic needs such as education, health care and nutritious food. Based upon the formulation of HDI, as per UNDP parameters on social development, estimations have been made to reflect possible changes in social well-being among people in India. Figure 5.6 shows the marginal income rise in per capita per annum due to bioenergy projects. Accordingly, if targets of biofuel programmes are met, marginal increase in per capita income is substantial to make visible changes in the life style of rural masses. Figure 5.7 shows the possible improvement in the HDI from bioenergy programmes. However, it should be for more exact calculations on social impacts, a large-scale study on primary data on social issues in affected rural areas is needed.



	2006-07	2011-12	2016-17
at 5% level	37.8	45.1	52.9
at 10% level	75.4	90.0	105.8
at 20% level	150.9	180.1	211.7

Source: Author's Estimates based on Data from UNDP and Various GoI Sources

Figure 5.6 Marginal income from biofuels (per capita per annum)



Source: Author's Estimates based on Data from UNDP and Various GoI Sources

Figure 5.7 Estimated HDI due to increased income

5.6. Summary and Conclusion

5.6.1. Overall conclusions

- In addition to economic gains in cost reduction of imported fossil fuels, development of bioenergy will result in energy security for the East Asian countries by diversifying the energy supply. Generating decentralized electricity, such as biopower through Biomass Gasifier Technology could be a boon to the people in remote areas. This would help transform the entire economic activities and life style of the people. A large part of rural population would be able to use the energy for various basic needs such as cooking, irrigation, education, etc.

- Growing more and more sugarcane may not be sustainable as it will reduce area under other food crops resulting in their price rise. While farmers with large holding may get benefited in short term, in the long run, all farmers and landless labourers may be affected adversely. Thus, complex analysis is needed to ascertain a balance between sugarcane and other crops for the production of ethanol.

- Due to easy access and wide spreading of Jatropha cultivation, at initial stage, some agriculture land may be used. But comparing Jatropha cultivation with Sugarcane cultivation, farmers may not find the former remunerative enough. For instance, in India, sugarcane plantations yield 70 ton per hectare and fetch the farmer Rs.70,000 per hectare at a sugarcane price of Rs.1,000 per ton. In comparison, with Jatropha plantation farmer gets Rs.5,000 per ton of oilseeds and if the yield is 3.75 ton per hectare, his income is only Rs.18,750 per hectare (UNCTAD, 2006).
- It is observed that end users care the most about cost of the product they buy and very few users think in terms of environmental benefits and social benefits to farmers or to the nation. In India, the cost of in-house production of ethanol and biodiesel is about US$0.40 per litre, which is about the same as for production of fossil petrol and diesel but higher than the import cost of ethanol and biodiesel (about US$0.20 per litre). Thus, production of biofuels, in case of escalating cost of petroleum could be beneficial for India. But the cost of production, both for economic reasons for the nation and attracting end users has to be kept low.
- Promotion of bioenergy would generate a large-scale employment in rural areas. For example, in India, by 2007-08, the first phase of the National Biodiesel Mission is expected to generate about 127.6 million person days to plant, 36.8 million person days to collect seeds and 1.35 million person days for running the

seed collection and oil-extraction centres. Similarly, marginal increase in sugarcane area will also generate rural employment.

- Increase in employment would generate extra income for individuals. Increased income may improve living standard and life style of people as they will be able to spend more on their basic needs such as food, education and health. Higher income in rural areas may also have positive impact on female literacy, uplifting of women and reduction in income disparity in rural and urban areas.
- Food versus fuel debate is more crucial for the East Asian countries. If prices of edible oil and other food items rise sharply, it will neutralize the positive impacts of bioenergy development. Also, in some countries, a large number of livestock heads use some crops and agro-residue as fodder. In addition, a large quantity of biomass is used as fuel for domestic cooking and other applications. Thus, any imbalance in food, fodder and other requirements, due to extensive use of biomass for energy, without any substitute, could create problems in rural areas.

5.6.2. Policy recommendations

- As far as possible, the existing agriculture land should be spared from, and the wastelands should be used for, growing biofuel crops. Land availability for biofuel crops is a crucial issue globally and to meet 5% blending demand by 2015, almost additional 100 Mha land are is needed across the world. Although total land available may be above 100 Mha but all of it can not be developed for biofuel crops (ET October, 2007). For heat or biopower production, through plants such as biomass gasifiers, focus should be on the use of agriculture waste.

- Small-scale farmers will be interested in cultivating the biofuel crops only if they are assured of higher economic returns. This necessitates introduction of mass awareness programmes and capacity building programmes in rural areas. In addition, financial and technical supports such as interest free loans or soft loans, easy availability of quality seeds and other inputs, crop insurance, etc. may be introduced. There is an urgent need of a policy for purchase of raw material from the farmers and biofuel from the producers at a guaranteed price.
- Along with sugarcane, some other raw materials such as sugar beet, sweet sorghum, and non-food crops and emerging technologies including cellulosic ethanol, may be tried for the production of ethanol. Sugar beet has certain advantages over sugarcane as it provides higher yield (12.5 to 17.5 ton per hectare of sugar against 7.5 to 12 ton of sugar per hectare from sugarcane). In addition, it requires lesser water and power for crushing and shorter maturity time.
- East Asian Countries could also explore a model similar to that of Brazil, where the ethanol blending ratio could be varied between E5 and E10, on an annual basis, depending on the availability of molasses and the economic and environmental rationale for ethanol production. Presently, upto 20% blending of ethanol is considered safe for use in automobiles without any modifications. East Asian governments may bring policy to encourage auto industry to use technology, which uses higher levels of blending.
- In some countries like India, lack of coordination between central and state authorities causes undue delay in commissioning and expansion of bioenergy

projects. Speedy clearance, preferably through a single window clearance policy, may be introduced to expedite various consents and permissions.

- Presently, only govt. agencies have been assigned the task of plantation on wastelands in some East Asian countries. It is needed that these agencies work in tandem with local people, NGOs and voluntary groups and create a sense of ownership among them. Involvement of women, landless labourers, marginal and small-scale farmers and other weaker sections of the society must be encouraged to reap the real social benefits of bioenergy programmes.

References

ADB (2007). *Key Indicators 2007.* Asian Development Bank, Manila, Philippines

Asianage (2007): Article by Dr. P.C. Alexsander, Former Governor of Maharshat and presently member of Parliament, (http://www.asianage.com/presentation /columnisthome / pc-alexander.aspx).

EthanolStattistics (2008): Ethanol Statistics website http://www.ethanolstatistics.com/.

FAO (2005): *Global energy partnership developed by the of Food and Agriculture Organisation; and Regional Wood Energy Development Programme in Asia* (http://www.fao.org/)

HDR, (2007): *Human Development Report 2007-2008*, United Nations Development Programmes.

HT (2008): *New India, Stories of Hope and Change*, Hindustan Times, Mumbai, Janaury 12, 2008.

HT, January 19, 2008: *Hindustan Times*, a repouted national daily, India.

IBFC, (008): Website of India Biofuel Corporation, http://www.ibfc.in/

India Vision-2020 (2004): *India Vision 2020*, Planning Commission, Government of India, New Delhi, Dec, 2004.

IEPR (2006): I*ntegrated Energy Policy Report,* Planning Commission, GoI, 2005.

KPMG (2007): *Report of KMPG in-India on "The Indian Sugar Industry, Sector Roadmap 2017*, June, 2007 (http://www.in.kpmg.com/pdf/ Indian_Sugar_ Industry. pdf)

MNRE (2007): *Annual Report of Ministry of New and Renewable Energy*, Govt. of India, 2006-07.

MoP (2007): Ministry of Power (http://powermin.nic.in/), Govt. of India.

MoA (2006): *National Oilseeds and Vegetable Oil Development Board*, Ministry of Agriculture, New Delhi.

NBL (2006): Website of Natural Bioenergy Limited (http://www.naturol-bio.com).

Newswire 18, (2007): UP govt to move SC against HC order on cane price, November 16, 2007.

Nishant Bioenergy (2006): Personal Communication with Mr. Ramesh Nibhoria , CMD of Nishant Bioenergy and details of Sanjha Culla on therir website (http://www.nishantbioenergy.net/).

Planning Commission (2003): Report of the Committee on Development of Biofuel, Planning Commission, GoI, New Delhi-110 001.

PFI (2007): Journal of Petroleum Federation of India (*http://petrofed.org/journal.asp*, April- June, 2007.

Raju, K.V (2006): *Biofuels in South Asia: An Overview,* Asian Biotechnology and Development Review, Vol 8, No. 2,

Sagisaka M. (2007): Personal Communication on his presentation on "Sustainable Biomass Utilisation Vision in East Asia."

Sarin R.(2006): Indian Oil Corporation, R& D Center, Faridabad.

Sharma V. K. (2000): *Energy Scenario in India*, Proceedings of the International Symposium on LCA, Proceedings of APEC/AIST/NEDO Symposium, NIRE, Tsukuba, Japan, December, 2000.

Sharma V. K. (1998): *Development of climate change impact model for India (water resources sector) submitted to the National Institute for Environmental Studies*, Japan Environment Agency, Japan, March, 1998.

TIFAC (2007): *Economics of Sugar, Ethanol, Power mix*, a report by TIFAC.

TOI (2007-08): T*he search for green fuel, a report published in the Times of India*, dated August 29 & 30, 2007 and various other issues of the Times of India during 2007-08.

UN-Energy (2007): *A UN document on "Sustainable Bio-energy: A Framework for Decision Makers."*

UNCTAD (2006): *"An Assessment of the Biofuels Industry in India"* prepared by Joseph B. Gonsalves, consultant to United Nations Conference on Trade and Development, Geneva, 2006.

UNDP (2006): *Human Development Report 2005-06*, United Nations Development Programmes.

WEO (2006): *World Energy Outlook*, International Energy Agency.

WDR (2008): *World Development Report 2008: Agriculture for Development,* the World Bank, Washington DC, USA.

CHAPTER 6

POLICY RECOMMENDATIONS

This report investigates various issues of 'Sustainable Biomass Utilisation Vision in East Asia.' The overriding benefits of biomass utilisation, as a source of renewable energy, are that it reduces the rate of depletion of fossil fuels and as shown in the preceding chapters, there are economic, environment and social benefits. At the same time, there are potential negative impacts and pitfalls associated with the development of biomass energy industry. To ensure that biomass utilisation remains a sustainable source of energy supply, the following recommendations are proposed.

6.1. Addressing Macro and Micro Levels Needs to Reap Maximum Economic Benefits

For a complete picture of the economic impacts of biomass utilisation, policy makers should consider not only the economic benefits at the national level, such as reduction of fuel import, increase in employment opportunities and revenue generation, but also the financial sustainability of the biomass energy industry within the local economy.

The business environment must be made favourable for the growth of the biomass utilisation industry. Regulations that mandate use of biofuels as fossil fuel blend, and various forms of direct or indirect subsidies may be needed to spur the growth of the biomass energy industry. However, such approaches are viable only for short-term gains and will not sustain the biomass energy business in the long run.

For long term sustainability of biomass energy programs, such policies should be implemented that will enhance the distribution of economic benefits to each stakeholder within the value-added chain; enhance profitability of the biomass energy business through maximising the biomass energy resources, use appropriate technologies; and adopt the most suitable form of material flow for conversion of feedstock to biofuel.

The economic benefit of the biomass energy industry should also be expanded to the development of other industries that are able to utilise their by-products as raw material. The investment environment for industry sectors such as the machinery sector for mechanisation and automation, the chemical sector, in particular, the agrochemicals sector, and the information technology sector for enhanced distribution network should also be conducive to support the growth of the biomass energy industry.

Maximum economic benefits from the biomass energy industry can be sustained through addressing both the micro and macro levels needs such as ensuring reliability of supply and stable pricing, in particular, for developing economies, where production of feedstock materials involves small-scale farmers.

In view of the diverse industry sectors and sub-sectors that are associated with the growth of the biomass industry, there are ample opportunities for the East Asian countries to work together for a sustainable demand and supply equilibrium of biomass energy within the region.

6.2. Enhancing Positive and Mitigating Negative Environmental Impacts

Most of the potential problems highlighted in the environmental aspects of biomass utilisation are related to agriculture activities and practices. The major environmental impacts associated with biomass cultivation include greenhouse gas emission and pollutants discharge from the production, distribution and application of different streams of materials, products and services required to produce the biomass feedstock; and loss of biodiversity through conversion of forest land to farm land.

There are also many positive impacts on the environment linked to the use of biomass energy, particularly when evaluated throughout its life cycle, i.e. from 'field to fuel'. Any biomass feedstock's value as a carbon neutral material is based on its ability to accumulate carbon during its growth and release the same amount during combustion, thus not adding any additional GHGs to the atmosphere. The positive environmental benefits of GHG reductions in biomass growth and utilisation can be realized as long as no large forest areas are cleared for agriculture production, and no over-harvesting of biomass is carried out. Proper planning and the sustainable management of agricultural land, along with control harvesting, will promote the sequestration of carbon dioxide via photosynthesis. The planted biomass, in particular for crops with long life span such as oil palms (25 years) acts as good carbon sink that sequester carbon dioxide for growth. Otherwise, changes in land use or large clearance of tropical forest to grow more biomass resources may end up emitting more GHGs than is intended to reduce.

Policies and strategies in support of biomass utilisation sustainability should be framed to enhance the positive impacts while mitigating the negatives. Adoption of proper water conservation and planning is encouraged, especially in rain starved areas. Supplemental irrigation and water harvesting methods have been among the methods proposed. Another policy should aim at GAP (Good Agricultural Practices), staring from a top-down approach, involving governmental support to the certification authorities, and finally, the training and education of farmers. Organic farming is one of the excellent agricultural methods as exemplified by certain palm oil plantations in Malaysia.

The impacts over the entire life cycle of the particular biomass energy should be considered and a technique such as Life Cycle Assessment (LCA) is adopted to rank the activities according to their contribution to the impacts. An activity or the stage of the life cycle that generates the most extensive damage for a particular impact category is referred to as a hotspot. The mitigation action plans, whether in the form of regulations, technological solutions, good practices or infrastructure development should be prioritised according to the ranking of the hotspots or the extent of damage of the impact to the environment.

6.3. Realising Direct and Indirect Societal Benefits or Returns

Societal impacts are not necessarily measured by direct monetary or tangible benefits. Well-developed biomass energy supply in the rural areas will lead to improved living conditions due to both increased income from employment opportunities and the availability of energy for better infrastructure, and public service facilities. These factors may contribute to increase in the level of literacy, in particular, among the rural female population, and promote gender equality.

There are, however, potential negative societal impacts that must be addressed to ensure sustainability of biomass utilisation. The foremost issue is of balancing food versus energy security. Care should be taken that the use of agricultural land for energy crops, the use of food crops as bioenergy feedstock, and consumption of agro-residues as fodder do not affect the food security. Policies should be designed in such a way that they benefit all strata of the society including land-less labourers, small-scale farmers, women and weaker sections. Large-scale mechanisation in biofuel plantation and other labour oriented activities should be avoided for better job prospects of rural population.

Policies that will demarcate arable landuse, promote cultivation of energy crops in waste land, wherever feasible, or apportion food crops that can be used for bioenergy production at the national level will ensure food security. However, in this context, studies should be conducted to establish the actual needs of each of the stakeholders to enable policy makers set realistic targets and controls.

6.4. Developing Sustainability Indicators to Enhance the Decision Making Process

Key performance indicators are already used by most Governments and businesses to assess the progress or success rate of policies and strategies, and communicate their performance to stakeholders. Sustainability indicators can be viewed as a sub-set of the generic key performance indicators, and are focused on characterising and reporting on the outcome of sustainable solutions.

Sustainable development indicators should address ecological, economic and social sustainability. At this juncture, there is no single indicator that is able to integrate all three aspects although there are indicators that do integrate at least two aspects. Eco-efficiency and Life Cycle Costing (LCC), for example, integrate environmental and economic aspects, while societal costs consider environment and society impacts.

A number of indicators of variable complexity can be applied to monitor the sustainability of biomass utilisation. Some can be as simple as employment generation, reduction in import, total value added, return on investment, increase in energy efficiency, and reduction in pollution load associated with a particular bioenergy industry with base comparison factors such as per unit of investment or land area.

In the absence of a singular indicator capable of integrating all three aspects, a suite of indicators is recommended. However, not every indicator need to be applied in the decision making process. Choice of indicator should depend on the relevance, type of background information available, and how the indicator value will be used in the decision making process.

In view of the wide choices of indicators that could be developed, there should be harmonisation on the use of specific indicators, at least at the regional level to enable Governments compare the effectiveness of national, regional or even international policies and strategies, and more importantly, to work towards some common goals under the 'Sustainable Biomass Utilisation Vision'.

Meanwhile, given the importance of the use of indicators in decision-making process, the integration of all three aspects into a single representative indicator should still be actively pursued. Emphasis should be given to develop new indicators that will address current and complex issues such as energy security.

6.5. Using Appropriate Tools to Generate Quantifiable and Verifiable Life Cycle Information

Appropriate evaluation tools or techniques will enable the generation of quantifiable information and data for incorporation into the sustainability indicators, benchmarking or other reporting applications. Among the evaluation tools that are able to systematically capture the impacts over the life cycle of a product or service is life cycle assessment (LCA). It is an established tool that can provide life cycle footprints for critical environmental impact categories such as green house gas emission, acidification, biodiversity and eutrophication. The use of LCA will also ensure that negative impacts are not passed from one environmental compartment to another, from one time frame to another, or from one region to another.

In the area of biomass utilisation, LCA can also provide quantifiable information to evaluate landuse in the context of optimised land size, the choice of crops, and comparison among various crops as bioenergy feedstock.

6.6. Considering Country-Specific Needs and Available Biomass Resources

Depending on the country's experience and needs, the driving force for the development of biomass energy production and utilisation in East Asia can be economic, environmental or social factor, or a combination of these factors. The ranking of importance of these factors is country specific. Examples of variations in country conditions include distribution of the biomass resources, large or small land holdings management, demand for the final product, availability of local technical expertise, labour skills, and seasonal supplies. These conditions will affect the extent of benefits gained from the biomass energy industry. Careful assessment is needed to ensure that appropriate decisions are made in line with the driving forces for sustainable biomass utilisation at national or country level.

6.7. Promoting Regional and International cooperation

At the regional and international levels, each country should respect the policies and approach that may be adopted by the other countries. Collaboration between bioenergy producing and bioenergy consuming countries in East Asia, to create mutual beneficial relationships covering technology exchange, capacity building and pricing controls, should be high on the agenda to sustain biomass utilisation from the economic, environment and social aspects.

At the regional and international levels, each country should pay due attention to the policies and approaches that are adopted by other Countries. Collaboration between bioenergy producing and bioenergy consuming countries in East Asia, including technology exchange, capacity building and appropriate pricing should be given priority for sustainable biomass utilisation.

For example, agriculture has been identified as one of the major contributing factors to negative environmental impacts through agrochemicals' application, water and land management. The environmental impact from use of the agrochemicals in agriculture can be reduced by improving the application practices at the farms or plantations, and also by improving the process of formulation and production of agrochemicals, most of which are produced outside the developing countries.

The recommendations presented above by the WG are not exhaustive and represent only the initial findings established from the ERIA Joint Research Project on ‘Sustainable Biomass Utilisation Vision in East Asia’ that officially commenced in October 2007. Many of the issues pertaining to sustainability of the biomass energy industry have been identified in the project. However, further in-depth investigation is required in order to find concrete solutions at the regional level.

APPENDIX

A1. TRENDS IN ENERGY RESOURCES AVAILABILITY AND USE

This section describes past and current energy utilisation in the East Asian countries considered and a global perspective.

A1.1. World

Present levels of global energy mix (in 2004) shows that biomass accounts for 10% (1,176 Mtoe) of the world's total (11,204 Mtoe). This further shows a reduced share of biomass from 16.5% in 1995 to only 10% in 2004 (Figure A1.1).

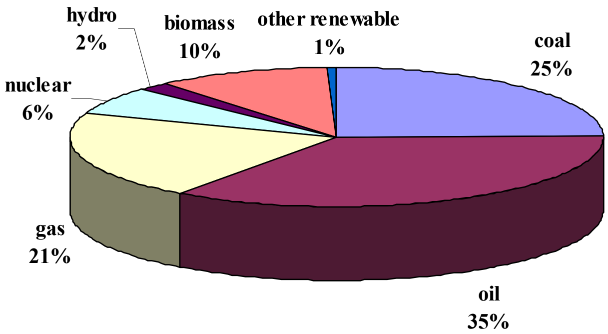


Figure A1.1 Global Fuel Energy Mix in 2004

Source: UNEP, 2007

A1.2. East Asia

Renewable energy sources account for 23% of East Asia's primary energy demand. Biomass, which is mainly used for traditional heating, is the main renewable energy source. Figure 3.3 shows the past trends of the amount of biomass utilised by some of the Asian countries with respect to the total energy supply of the region.

In 1997, energy from biomass such as wood and agricultural residues represents about 40% of total energy consumption - more than 2.5 million Terajoules per year. The bulk is from wood fuels, with an estimated value of $7 billion per year. Main applications are in the domestic sector and small-scale industries, but also increasingly in modern systems for combined heat and power generation.

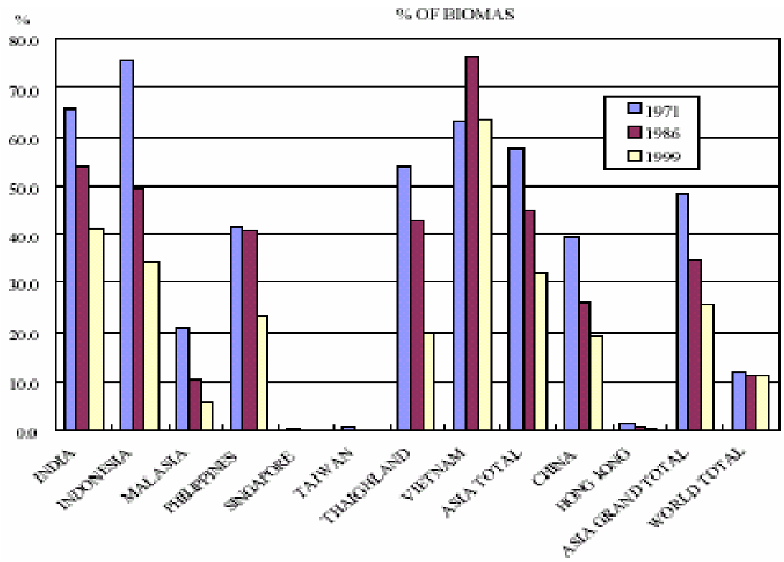


Figure A1.2 Share of Biomass to Total Energy Supply in Asia

For the five ASEAN countries where biomass is an important energy source (Indonesia, Malaysia, Philippines, Thailand and Vietnam), consumption increased on average 2% per year between 1985 and 1994, mainly due to population growth. Consumption is highest in Indonesia, accounting for more than half of the total consumption because of the large population, while the rate of increase is highest in Malaysia and Vietnam.

Primary energy consumption in the Asia-Pacific region grew by an annual average rate of 6.2% from 1980 (1,163.8 Mtoe) to 2000 (2,607 Mtoe) (BP Global, 2006). During the same period, coal and oil dominates the modest contribution of renewable sources. In eight selected countries in Asia, reliance on fossil fuels is rising sharply but the fast increase in use of renewable energy resources is also evident (Figures A1.3 and A1.4).

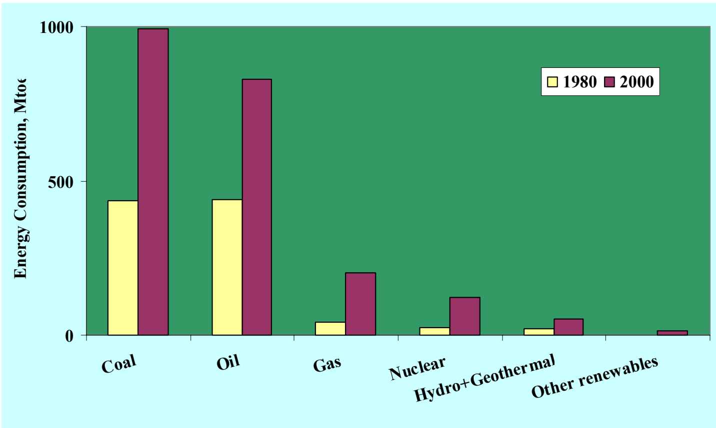


Figure A1.3 Trends in Primary Energy Consumption
by Fuel Type in 8 Asian Countries

Source: Asian Energy Outlook to 2020

In year 2000, total primary energy consumption in the eight selected countries in Asia mostly was derived from fossil fuels. Coal and oil accounted for 82.5% of this energy mix (45 and 37.5%, respectively); together, natural gas, hydro and geothermal, biomass (renewables) and nuclear power contributed the remaining 17.5%. Country energy mixes vary greatly: coal is the dominant source of energy in China (70%) and India (54.6%), while oil figures more prominently as a source of energy in Japan, Korea, Indonesia, Malaysia, Philippines and Thailand (OECD, 2007). Throughout the entire region biomass continues to supply a significant portion of the primary energy mix, mostly in the form of traditional fuels used by rural households and the urban poor (Figure A1.3).

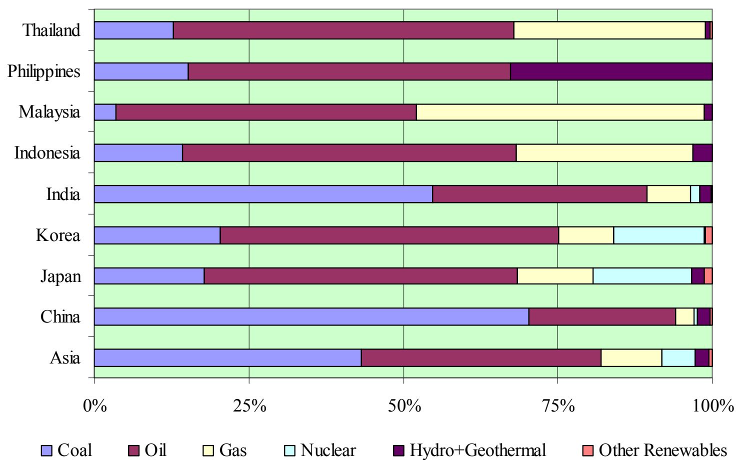


Figure A1.4 Primary Energy Mix by Fuel Type in 8 Asian Countries (2000)

Source: Asian Energy Outlook to 2020

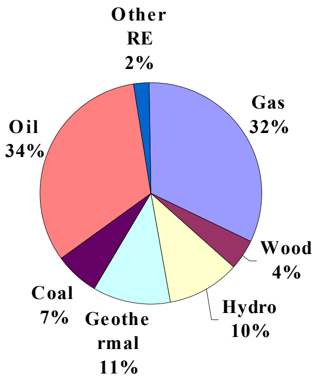
In the Philippines, biomass contributed about 32% of the total energy mix in 2006. Biomass, by far, is the largest contributor among the indigenous sources of energy. The Department of Energy projected that biomass contribution would exhibit a declining trend up to 2014 wherein its share in the energy mix would only be 24%. However, its contribution in terms of volume expressed in million barrels of fuel oil equivalent (MMBFOE) is increasing.

Despite biomass' decreasing share in the energy mix, an optimistic trend was observed for coconut methyl ester and ethanol utilisation which would increase in the coming years.

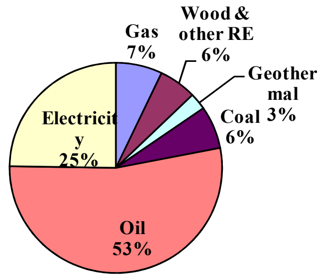
A1.3 New Zealand and Australia

In 2002, New Zealand's total primary energy supply was 756 PJ. Oil accounted 33% (251 PJ) of the total primary energy supply, followed by gas at 32% (243 PJ), geothermal at 11% (83 PJ), coal at 7% (78 PJ), wood at 5% (34 PJ), and other renewable sources at about 2% (16 PJ) (Figure A1.5a).

During the same year, final energy consumption was dominated by oil, comprising 53% (269 PJ) of the total final energy consumption of 505 PJ. Electricity accounted for 25% (125 PJ), coal at 6% (33 PJ), gas at 7% (36 PJ), and geothermal at 3% (13 PJ). Wood and other renewable sources made up the remaining 6% (29 PJ) (Figure A1.5b).



a) Primary Energy Supply



b) Final Energy Consumption

Figure A1.5 New Zealand's Primary Energy Supply and Final Energy Consumption in 2002

Source: NZ Ministry of Economic Development, 2003

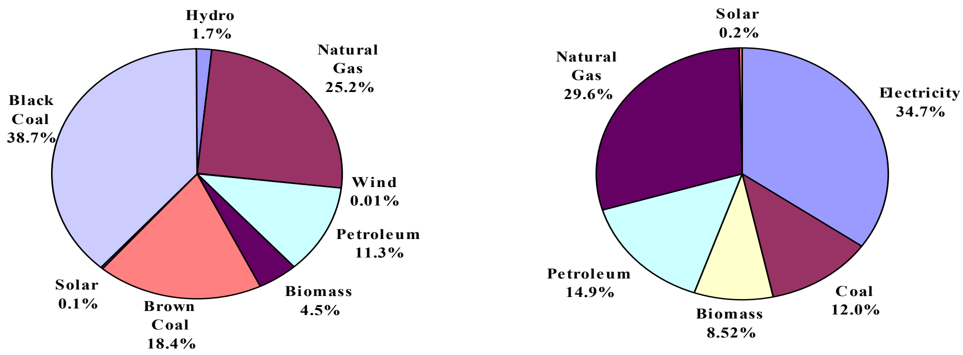
On one hand, total stationary[4] primary energy consumption in Australia was 3,605.3 PJ in 2001. This figure includes all energy use, except final energy

4 Stationary energy means all energy use other than for transport.

consumption of fuels other than electricity for transport, and is equivalent to 186 GJ per head of population. It is dominated by coal (brown and black) which accounts 57.1% (2,060 PJ), followed by natural gas at 25.2% (910 PJ), petroleum at 11.3% (408 PJ), biomass at 4.5% (163 PJ), and solar, hydro and wind making up the remaining 1.8% (64.3 PJ) (Figure A1.6a).

Of the total primary energy consumption, 2,139 PJ were used in electricity generation and supply, and 229 PJ in other energy processing activities, such as oil refining. It can be seen that coal, most of which is converted to electricity for final use, accounts for well over half of total stationary primary energy consumption. Quantities of petroleum used are relatively modest, as this is predominantly the fuel used for transport sector.

During the same year, final energy consumption was dominated by electricity, comprising 34.7% (651 PJ) of the total final energy consumption of 651 PJ. Natural gas accounted for 29.6% (556 PJ), petroleum at 14.9% (280 PJ), coal at 12% (226 PJ), and biomass at 8.5% (160 PJ) (Figure A1.6b).



a) Primary Energy Consumption b) Final Energy Consumption

Figure A1.6 Australia's Stationary Primary Energy and Final Energy Consumption in 2001 (Sadder H. et. Al. 2004)

A2. FUTURE ENERGY DEMAND GROWTH

If current trends continue, primary energy consumption in the eight selected countries in Asia will increase by 89% from 2,206 Mtoe in 2000 to 4,171 Mtoe in 2020. Energy demand in Asia is expected to reach 4,570 Mtoe by 2020, accounting for 33 percent of global energy demand (Asian Energy Outlook to 2020).

Though the current rate of growth in the renewables sector is fast, only modest increases in supply are projected unless greater growth rates are realized in the future. With projected increase in China's share of global energy demand from 10% in 2000 to 15% in 2020, it is also expected to lead the region in terms of renewable energy consumption at 35 Mtoe by 2020 (Asian Energy Outlook to 2020).

New Zealand's primary energy supply is projected to grow at an annual average rate of 1.1% from 756 PJ in 2002 to 903 PJ by 2020. Growth is due to several factors including costs, changing availability of energy sources, technology and climate change considerations. Prominent examples of such factors are the depletion of the Maui gas field, the potential increase in the use of wind and geothermal energy and the government's ratification of the Kyoto Protocol (NZ Ministry of Economic Development, 2003).

Final energy consumption in New Zealand is projected to grow at an annual average rate of 1% from 505 PJ in 2002 to 599 PJ in 2020. This comprises electricity demand increasing by 1.2% per annum (pa), gas by 4% pa, oil by 0.72% pa, biomass by 2.3% pa, and coal by 1.3% pa (NZ Ministry of Economic Development, 2003).

The foregoing projections for New Zealand energy sector was based on a number of assumptions under the Reference scenario considered by the Ministry of Economic Development. Key assumptions include: GDP growth of 2.5% pa from 2007, oil prices rising from US$ 20/bbl in 2004 to US$ 25/bbl by 2020, constant exchange rate at NZ$ 1 = US$ 0.5 up to 2025, Pohukura and Kupe gas fields available in 2007 and 2008, respectively.

On the other hand, Australia's stationary final energy demand is projected to grow at an annual average rate of 1.5% from 1,877 PJ in 2001 to 2,943 PJ in 2040. By this time, energy mix will still be dominated by electricity – 38.3% (1,127 PJ) and natural gas – 27.4% (807 PJ). Biomass contribution will slightly decline from 8.5% (160 PJ) in 2001 to 6.9% (204 PJ) in 2040, though its actual figure of consumption has increased. In these projections, key assumptions used are: the energy intensity change for the whole economy, i.e. aggregate energy intensity of the Australian economy, was -1.4% pa with GDP used as the overall measure of production. It is further assumed that there would be a shift within the economy towards a greater emphasis on sectors which are less energy intensive, such as services, and away, in relative terms, from more energy intensive sectors, such as chemicals and metal processing (Sadder H. et. Al. 2004).

The International Energy Outlook 2007 considered a reference case scenario for projecting the world's total marketed energy consumption. This scenario assumes that current laws and policies remain unchanged throughout the projection period.

Total world consumption of marketed energy is projected to increase from 11,204 Mtoe in 2004 to 17,095 Mtoe in 2030—a 53-percent increase over the projection period.

Much of the growth in energy demand will occur in Asia. Energy demand in Asia is expected to grow from 3,471 Mtoe in 2004, accounting to 31% of world's total, to 4,307 Mtoe (33%) in 2010 and to 6,926 Mtoe (40%) by 2030 (Table A2.1).

Table A2.1 Projections of Marketed Energy Consumption in Asia and World (2010-1030)

Year	Marketed Energy Consumption (Mtoe)	
	Asia	World Total
2010	4,307 (33%)	12,882
2015	4,960 (35%)	14,099
2020	5,613 (37%)	15,299
2030	6,926 (40%)	17,095

Source: Energy Information Administration, 2007

References

Energy Information Administration. 2007. International Energy Outlook 2007. Retrieved from the EIA on-line database on the World Wide Web: http://www.eia.doe.gov/oiaf/ieo/index.html

Kokichi Ito, Li Zhidong, and Ryoichi Komiyama. 2005. Asian Energy Outlook to 2020: Trends, Patterns and Imperatives of Regional Cooperation. RIS-DP # 93/2005. Research and Information System for Developing Countries, New Delhi, India. Retrieved from the RIS on-line database on the World Wide Web: http://www.newasiaforum.org/dp93_pap.pdf

New Zealand Ministry of Economic Development. 2003. New Zealand Energy Outlook to 2025. Energy Modelling and Statistics Unit Resources and Network Branch, Wellington, New Zealand. Retrieved from the NZ MED on-line database on the World Wide Web: http://www.med.govt.nz/upload/27823/outlook-2003.pdf

OECD. 2007. Country Statistical Profile 2007. Retrieved from the OECD on-line database on the World Wide Web: http://stats.oecd.org/WBOS/default.aspx?DatasetCode=CSP2007

Saddler, H., Diesendorf, M. and R. Denniss. 2004. A Clean Energy Future for Australia. Energy Strategies for the Clean Energy Future Group, Australia. Retrieved from the Clean Energy Future Group on-line database on the World Wide Web: http://www.wwf.org.au/publications/clean_energy_future_report.pdf