Chapter 4

Environmental Aspects of Biomass Utilisation

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CHAPTER 4

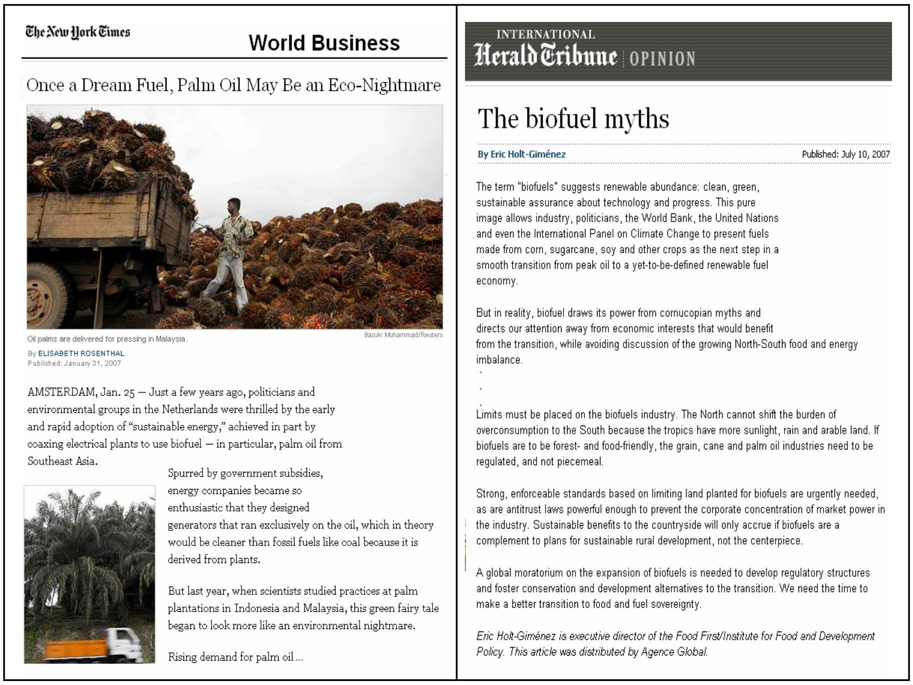
ENVIRONMENTAL ASPECTS OF BIOMASS UTILISATION

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).

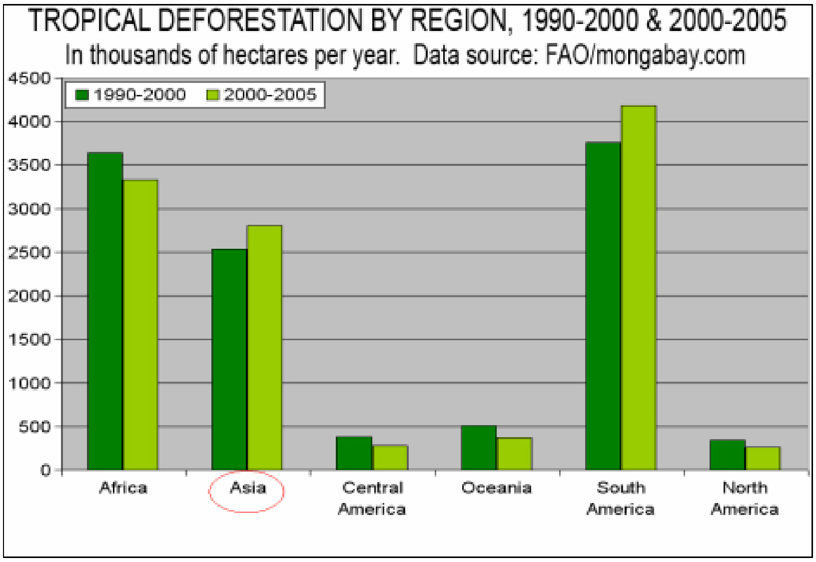


Fig. 4.2: Tropical deforestation rates by region

Source: FAO

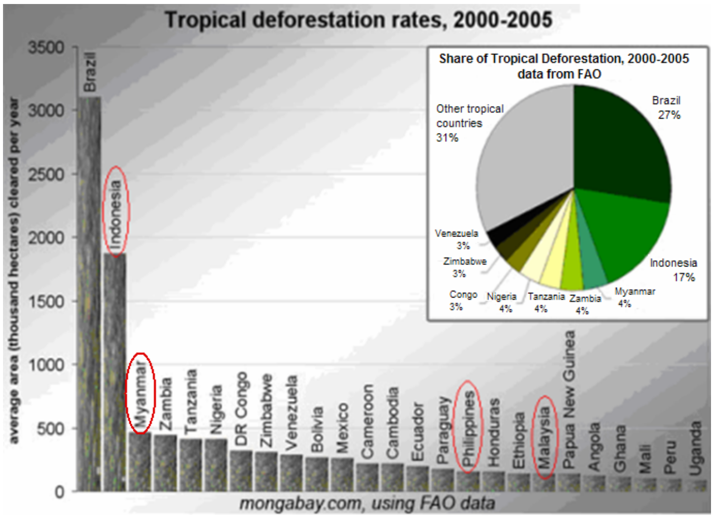


Fig. 4.3: Tropical deforestation rates for selected countries from 2000 - 2005

Source: FAO

Tropical forest areas are recognized as an important sink for carbon dioxide (CO2) 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).

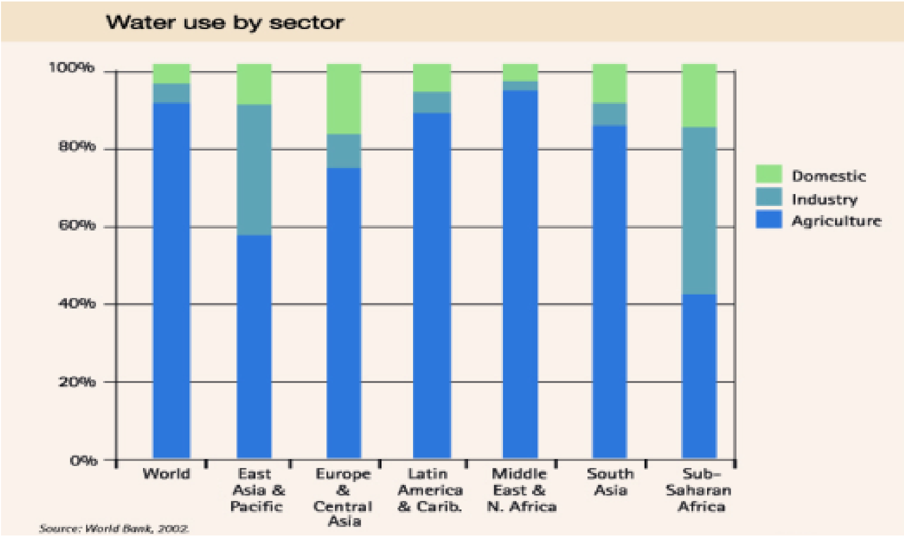


Fig. 4.4: A large portion of the world's water is consumed by agriculture

Source: Water Resources of Earth

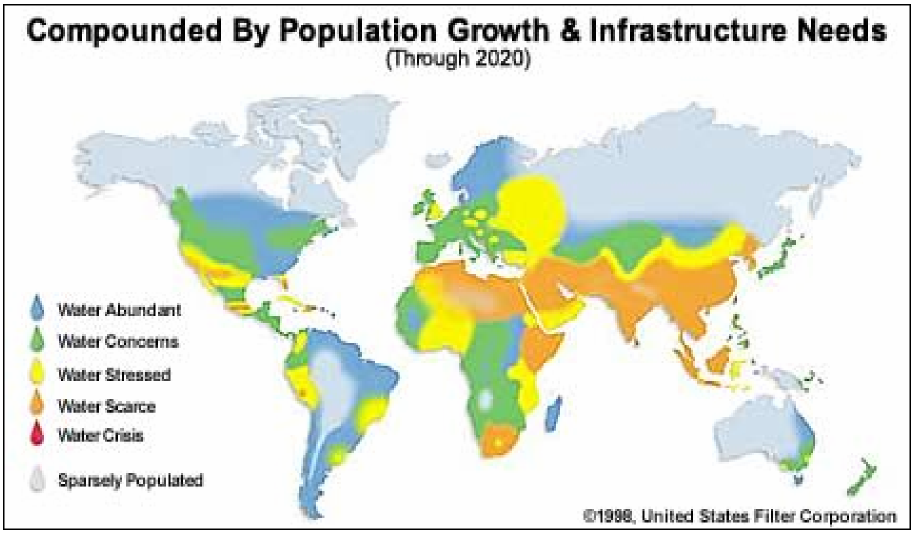


Fig. 4.5: Worldwide places that are facing water scarcity

Source: United States Filter Corporation

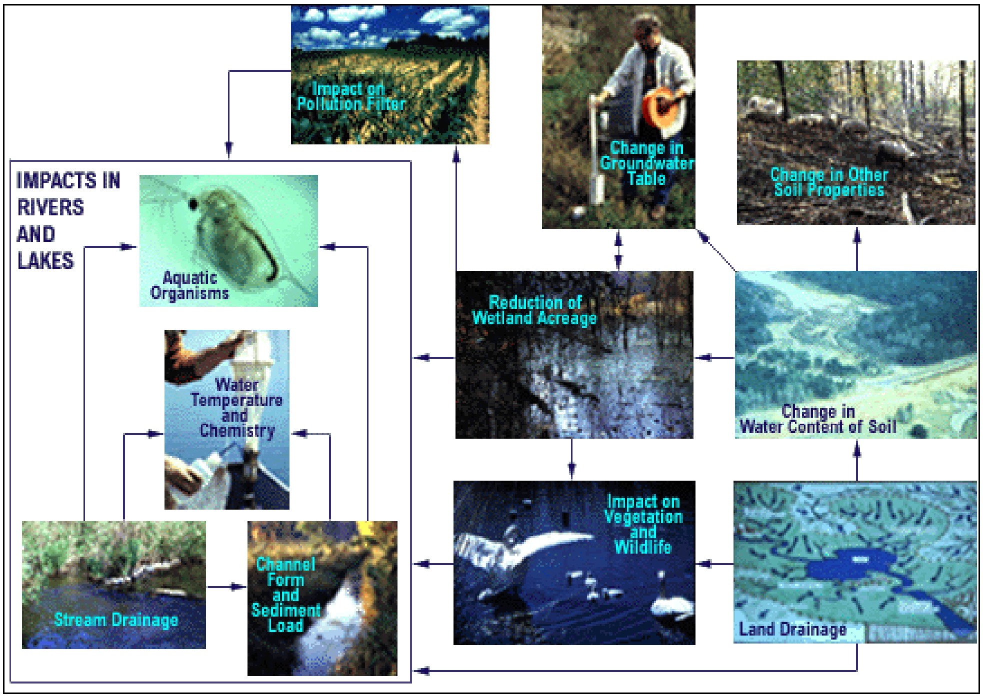


Fig. 4.6: The impacts of agricultural drainage to water, plants, wildlife and other ecosystem properties

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).

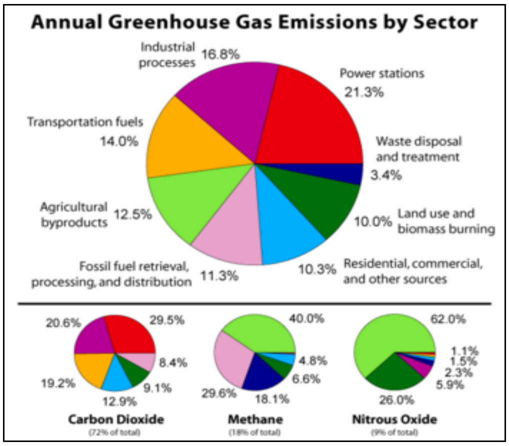


Fig. 4.7: Global anthropogenic greenhouse gas emissions for 8 different sectors for the year 2000

Source: United Nations Environment Program

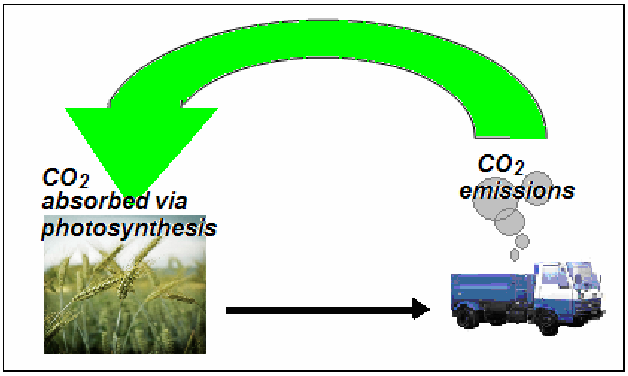


Fig. 4.8: ‘CO_2-neutral’ concept of biofuels is being subjected to debates

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).

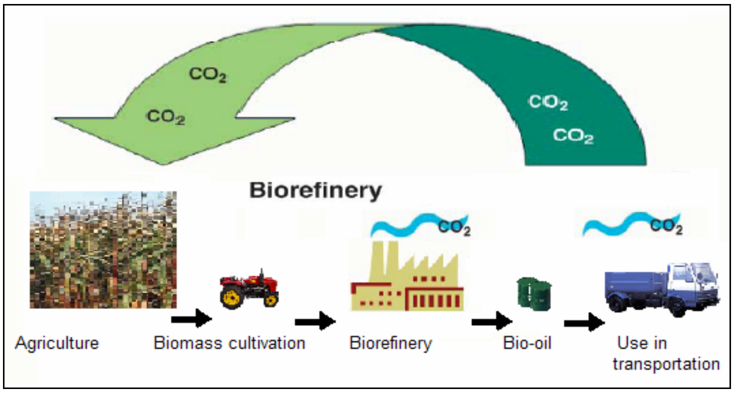


Figure 4.9 Life cycle carbon footprint gives a more complete account of the total CO_2 sequestered or emitted

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.

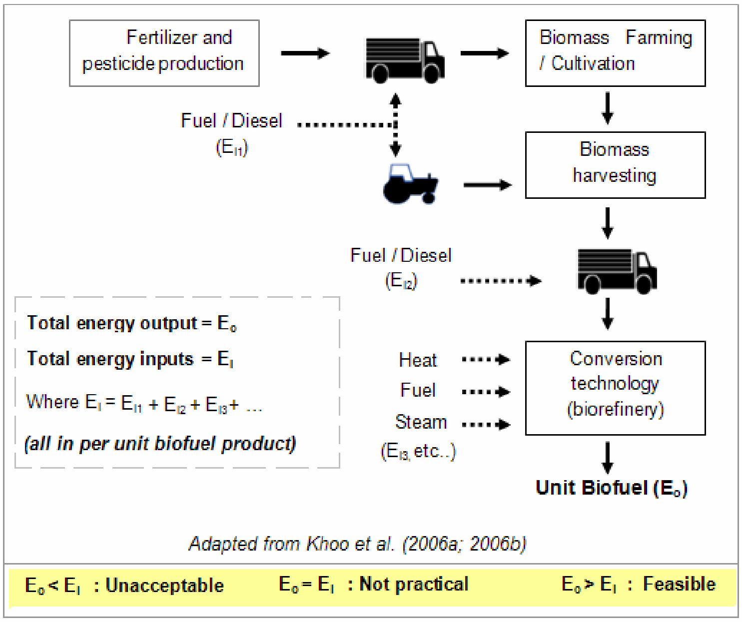


Figure 4.10: Energy balance calculations for biofuel production

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).

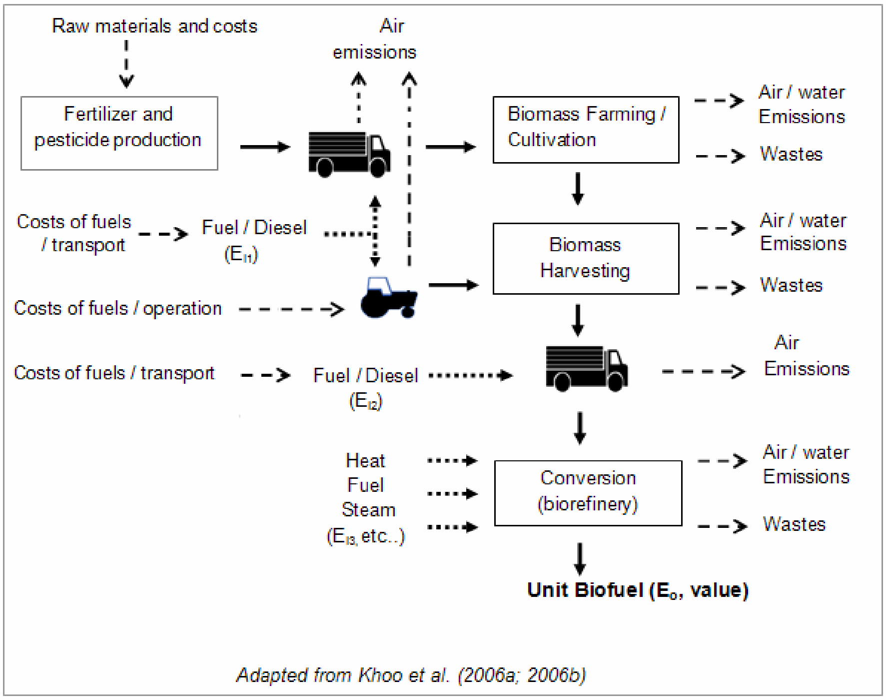


Figure 4.11: Life cycle management of biomass-to-biofuel to measure all associated energy/resource consumption, emissions and costs (optional)

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.

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