Oil Palm Plantation: Meeting Demands and Challenges[1]

By
Y Bhg. Dato' Dr Mohd Basri Wahid,
Director General,
And
Dr Chan, Kook Weng,
Senior Research Fellow,
Malaysian Palm Oil Board,
6, Persiaran Institusi, Bandar Baru Bangi,
43000 Kajang, Selangor, Malaysia

Abstract

The paper explores the production, demand and challenges of the oil palm crop to provide sustainably food from palm oil and potential renewable energy from biomass for local and export markets. This new twin strategy addresses the simultaneous concerns for food and energy production to be green on one hand, by reducing the impacts on food distance travelled, CO_2 emitted, waste utilised and renewable energy generated; and sustainable on the other hand, by enhancing development of environmental integrity, economic profitability and social equity. Important aspects of greenness and sustainability over the whole supply chain are examined and assessed holistically to ensure that both food and bio-energy production can reduce food miles through livestock and crop integration, utilise waste by recycling as nutrient substitute, slow climate change by delivering real greenhouse gas (GHG) savings, and meet sustainability criteria. A legislative framework to promote security of food and renewable energy is needed to provide the industry and business community with long-term stability and be on track towards a cleaner, more secure and more competitive future. Supporting evidence on such quantification be communicated through eco-labels reporting either a single or multiple attributes or focusing on a single phase or a full life cycle of the products.

The Malaysian oil palm industry's response to meet the demands and challenges posed by exploiting the synergy between food and bio-energy production is to gain considerable improvement through i) Crop breeding and biotechnology to address yield increase ii) Avoidance of food versus fuel issue by utilising the large unexploited biomass to meet the demands of the EU Biofuel Directive iii) R&D into second-generation feedstock and conversion technologies of biomass iv) Mitigating climate change through the United Nations Framework Convention on Climate Change (UNFCCC) Kyoto Protocol (KP)'s Clean Development Mechanism (CDM) and International Emission Trading (IET) to obtain carbon credits from net carbon balance v) Sustainability certification with Certificate of Assurance (COA), Code of practices (CoP) and Roundtable Sustainable Palm Oil (RSPO) to enhance soil quality and fertility, biodiversity and hydrological protection vi) Diversify into crop and livestock integration to increase land productivity and cut down food miles and vii) Policy needs to provide incentives for delivering low GHG food and biofuels under wider environmental, social and economic benefits.

---

[1]Paper delivered at the 2nd International Plantation Conference and Exhibition (IPICEX2008) of *"Reinventing the Plantation Sector: Globalisation, Diversification and Environmental Issues"* held at the Grand Blue Wave Hotel, Shah Alam, Selangor, from 18-21 November 2008.

Introduction

The year 2008 saw the unprecedented escalation of the prices of crude fossil oil from USD59/barrel at the beginning of the year to doubling at USD149/barrel by middle of the year and rapidly dropping after the hike to below USD70/barrel by October 2008. While we need to study the causes of these gyrations, the escalation of energy prices has multiple dimensions leading to the fear of another economic meltdown never seen before. At the height of the hike of crude oil price exceeded USD150/barrel, there was credit crunch with some established banks collapsing followed by the credit crisis with bail out of some financial institutions by their Government and all these were different from the last experience of the Asian financial meltdown. Even as the global economy recovers, there is the fear that the crude oil price will return to USD100/barrel. This is because the world has not invested enough in sourcing for new energy resources and there was an over reliance on the OPEC countries for oil supply. The OPEC supply growth had stagnated since 2003 yet the long-term growth demand had outstripped supply growth. This is worrying as the global community is dependent on fossil oil especially the Asian giants like China and India, for development. The price hike is therefore a threat to the world economy that is driven by energy. Further the world economy, being interdependent, must tackle this dilemma together as energy security has become a universal issue.

Over the last few years, the world is responding to the energy security situation by moving away from consumption of fossil fuels and look at the multiple sources and types of alternate energy. The word is diversity of fuel sources and it is not an 'either' 'or' situation because global trade and energy are interconnected. Therefore for each country, the energy mix being different should capitalise on its strengths.

In Malaysia how did the oil palm industry respond?

Energy security being a global issue and interlinked with economy and trade will affect the palm oil market. Being global, palm oil trade itself is interlinked with sustainability challenge. Whatever we do locally with the best practices within our oil palm plantation environment will have an effect on our production and export which themselves are influenced often by externalities beyond our control. Palm oil in 2007 together with crude oil and gas contributed to about 15% of Malaysian exports and 9% of the GDP. To continue to be an effective contributor to national economy in 2008, the oil palm industry operation must remain well integrated with good quality control and food safety measures of products manufactured throughout the supply chain but externalities affected us.

The first half of 2008 saw the CPO prices reaching new heights with the peak at RM4,468/t in March 4 yet for the next few months the fortune was reversed with prices bottoming out to RM1450/t. The whole episode offers the palm oil industry many new insights of how a well performing industry can have its fortune reversed by external factors beyond its control. The industry now wants to know, like a good doctor on how to diagnose, then prescribe before applying treatment, to any such symptoms as they serve as an early warning of future development in the global front for an impending world recession. Two scenarios were observed:

On one hand, under normal circumstances, the oil palm industry being efficient with all costs well-monitored from land preparation, planting, harvesting, production to marketing, is sufficient to ensure that the important requirement of keeping operational cost low between RM 680-850/t FFB and producing high fresh fruit bunch (FFB) yields between 25-35t/ha/yr to remain profitable.

On the other hand, under the violent fluctuations of a rapid rise and decline of CPO prices as had happened where during the first half of 2008 the prices rose up to the higher range with monthly price averaging at RM3,680/t and with the highest price reached at a record at RM4,486/t on March 4 2008 and was followed in the second half year by a rapid fall of prices of CPO slumping and plummeted to RM1870/t in October 2008. This pattern followed the trend of crude oil prices. Despite this, the plantation companies were able to obtain very good returns especially when the prices were on a rising trend by adopting a flexible strategy for the sales of CPO and judiciously adjusting the forward and spot sale percentages to meet the price trend. With this strategy, even as the prices of CPO felled, the plantation business still gained but realised smaller margins.

However soon fear crept in when some companies reported to be barely making profit though the efficient ones could withstand further fall but they ultimately too would also experience break-even should the CPO prices fall around RM950/t. For the smallholders, there was anxiety as the drop of FFB prices from the height of RM708/t FFB in March 2008 to RM428/t in September 2008 and then to RM261/t in October 2008 affected their earnings since they traded only in FFB sales. Indeed, the fluctuation in trading of palm oil at RM3,680.50/t in March 2008 and dropping to RM1,873.50/t in October 2008 was confirmed by MPOB. In fact CPO prices in Malaysia had been traded at low of RM1,556/t, a drop of nearly 65% in prices from its March record (The Edge, 2008).

As the price trend of CPO followed that of the crude oil where it remained high during the first half of 2008 following the escalation of crude oil to over USD140/barrel a third factor correspondingly entered the scene. It was the raising of the prices of the fossil fuel-derived resources like fertilisers, pesticides and chemicals which are inputs for the oil palm industry. The high input costs soon raised the cost of production per tonne of FFB. The high cost of fertilisers for example coming from their production, processing, transport and surcharges - the latter of which accounted for 60-70% were passed to local consumers in the plantations. Fertilisers, like 'Muriate of Potash' rose to about RM3,300/t compared to RM2,000/t in March 2008. Thus the overall cost of producing CPO was raised ultimately to RM1300/t. This is because there was no relief of price reduction of fertilisers when crude oil price started to drop in the second half of this year. There is a government move to scrap import duty on fertilisers so that commodity producers can get a respite (Business Times, 2008).

Several impacts were observed when the disjointed rise in fertilizer cost on production cost without reduction in prices when the drastic drop of CPO prices commenced. They were:

i) Palm oil contracts with some traditional buyers started to be defaulted as a result of fast falling prices of palm oil (Hindu Business, 2008),
ii) There were deferments in shipments and renegotiations of deals (The Star, 2008),
iii) With deferments, excessive global stocks started to build up,
iv) Deepening worries about the likelihood of a worldwide recession soon caused the industry to be among the many badly hit producers of commodities as prices plunged and remained low and

v) The oligopolistic output of palm oil from Indonesia and Malaysia estimated to be 20 and 17.8 million t respectively and amounting to 80% of the world palm oil in 2008 (The Star, 2008) made the governments of both countries to take collaborative action to control, influence prices and affect positions of competitors.

Thus amidst this potential gloom, the industry acted quickly on two other fronts to avert the threat by:

- Strengthening the existing contacts with the present customers and establishing new ones with emerging customers
- Exploring new and exciting technological development for the industry to participate in energy security sector on a commercial scale as exemplified by the announcement of the government to implement B5 biofuel on all government vehicles.

This heralded the industry's real march to ensure its bio-energy business decisions are following the signals of the market and technological trends so as to contribute its part to avert the global energy crisis.

Food and Bio-energy: Dawning of A New Initiative

The falling margin on profits, fuelled by the rising cost of energy of products derived from petroleum, was an opportune time for the industry to strategically want to help the country by providing leadership both nationally and internationally on a new initiative by looking at the prospects of palm oil as food and biomass as feedstock for a bio-energy and renewable energy production. Both the private sector and the Government responded to this opportunity by:

- On the private sector side, the excess stock of palm oil according to the Associated Chinese Chambers of Commerce and Industry of Malaysia (ACCCIM), amounted to 1.5 million t could be used for biodiesel production (News Straits Times, 2008). In fact one Malaysian company, Desmet Ballestra, had been providing such leadership as it found the declining CPO price trend to be an opportunity for biodiesel production rather than a threat. Being involved in the setting up of biodiesel plants, where it had set up some ten biodiesel plants and sixteen palm oil refineries worldwide, the current situation opened the demand for more infrastructure to be constructed to produce bio-energy biodiesel following decline of CPO prices (Kingsman, 2008a).
- On the Government side, the Malaysian Cabinet Committee (MCC) following the announcement to implement a 5% biodiesel blending policy from February 2009 for all government vehicles, the exercise would be expected to use up 500,000 t of CPO/year (Kingsman, 2008b) thereby bringing down the excess stock made.
  The government further announced a two-pronged strategy.
  - One was the government announcement of a RM200 million allocation for oil palm replanting of 200,000ha of low yielding old palms (Bernama, 2008) and
  - The other was the announcement of another RM200 million allocation to help biodiesel players to set up infrastructure construction (Kingsman 2008c).

  In fact, the MCC on the Competitiveness of the Oil Palm Sector chaired by the Prime Minister of Malaysia said "*Palm oil is used not only to produce foodstuff but also in* *making cosmetic and medical-related items and may be used as fuel to meet our needs*"(Kingsman 2008b).

Thus the stage is set to look at the demands and challenges of the Malaysian oil palm sector to be a serious provider of food and fuel simultaneously.

Aim of Paper

The aim of this paper is to examine the complexities of the opportunities and implications that may arise from meeting the demands and challenges of producing both palm oil as food and bio-energy for trade in the international market. As the Malaysian oil palm industry ventures seriously into simultaneous diversification into supplying both food and bio-energy, a full picture of how complex this integration of food and biofuel production will be will unfold under widely differing environmental, social and economic situations. Such an examination is in line with Vision 2020 where *"Malaysia should not be developed only in the economic sense, it must be a nation that is fully developed along all dimensions economically, politically, socially, spiritually, psychologically and culturally"*. The Malaysian palm oil industry is now posed to play its part and contribute towards such development to be a provider of both food and energy security.

As the demands and challenges for production of both the palm oil as food and biofuels start to play out, it becomes clear to the industry needed some guiding principles and three were crafted as follows:

- Firstly, the industry strongly believes that any active move forward into food and bio-energy production should be focussed on the second-generation technologies where the biomass feedstock is converted to biofuels thereby avoiding the "food versus fuel" debate in which the first generation biofuels production technology is relying on the transesterification to palm oil to biodiesel should only be done to mop up excess palm oil stock.
- Secondly, the industry must explore the potential barriers that may come out which are not on the current agenda of the World Trade Organisation when palm oil is traded only as food but now as food and fuel.
- Thirdly, as the food and bio-energy industry develops, the creation of new market opportunities for palm oil would likely to expand but would require the industry to demonstrate the life-cycle accounting of GHG emissions reduction with the best practices implemented to show that palm oil and bio-energy production will result in a positive carbon balance thereby fulfilling the need to slow down of climate change.

Thus the paper will discuss the complex interaction of opportunities and threats, implications and barriers, and weaknesses and strengths of the Malaysian oil palm industry as it responds to the new demands and challenges arising from the four global needs of:

i) to reduce food miles,
ii) utilise waste,
iii) slow down climate change by reducing GHG emissions and
iv) meet sustainability criteria

when exploiting the synergy of food and bio-energy production.

Considerable improvement will be gained from doing an in-depth examination of the SWOT analysis into the following seven focussed areas:

- Crop breeding and biotechnology to address the need for higher oil palm yield and efficient bio-energy feedstock production.
- Avoidance of “food versus fuel” issue by utilising the large quantity of unexploited available biomass to meet the criteria as demanded by the EU Sustainable Biofuel Directive for feedstock production and conversion processes.
- R&D into second-generation biofuels from feedstock and technologies using the biomass in such proportion where its use would not affect mulching for productivity in the field. Further the resulting pollution loading from air, water, toxic and solid waste streams do not aggravate the fragile ecosystem.
- Mitigating climate change through the flexible mechanisms of the United Nations Framework Convention on Climate Change (UNFCCC)’s Kyoto Protocol (KP) of hosting Clean Development Mechanism (CDM) projects by developing countries and funding by the developed countries to obtain the carbon credits from the net carbon balance for trading under the International Emission Trading (IET) scheme must consider moving forward to look into afforestation, reforestation, avoided deforestation (AD) and Reduced Emissions from Degradation and Deforestation (REDD) as cost-effective GHG emission reduction projects come post-2012 after Kyoto.
- Sustainability by certifying that palm oil is legitimately produced on approved agricultural land through issuance of the Certificate of Assurance (COA), by implementing best practices to enhance soil quality and fertility, biodiversity and hydrology with minimal impacts over the entire supply chain through issuance of Codes of Practice (CoP) certificates and by supporting sustainable palm oil through issuance of Roundtable Sustainable Palm Oil (RSPO) certificate.
- Diversification of crop and livestock integration to increase productivity per ha yet cutting down the unnecessary food miles for food import, and
- Policy needs to provide some incentives that would deliver low GHG food and bio-energy thereby generating wider environmental, social and economic benefits to Malaysia.

Background for Implementation of the Food and Bio-energy Development

Bio-energy is energy generated through biofuels. On a global scale, the world consumes about 400EJ (exajoules) of energy per year but generates about 100EJ of largely unused crop residues (De La Torre Ugarte, 2006). Modern biomass can easily produce another 180EJ from energy dedicated crops and trees, yet despite this, the potential bio-energy is viewed not as a major replacement for fossil oil but as a renewable energy (RE) source. This is because:

- The production of energy from biomass involves a wide range of technologies such as solid combustion, gasification, and fermentation that are applied onto a wide range of biological resources like crop residues, wastes, methane trapped from effluent ponds, manure and dedicated energy-crops.
- The resultant energy is used in many ways for cooking, heating, lighting, electricity generation and for transportation fuels, all of these contribute to potential path towards environmental, social and economic benefits and energy security.

- Applying the range of technologies to produce liquid and gas biofuels from such a diverse set of biological material of crop residues, co-products, wastes and manure nevertheless as RE accounts for only 10% of the total world energy supplies.
- However RE can form about 33% of the energy use in developing countries as compared to about only 3-4% in developed countries.
- The use of bio-energy therefore varies widely among the developing countries where biomass accounts for a high of 60% of the final energy in Africa, 34% in Asia and 25% in Latin America (Hazell and Pachauri, 2006).

In the context of the Malaysian oil palm industry, the main sources of bio-energy are from the agricultural residues which are also the considered as the co-products from palm oil production. Bio-energy in the industry is attractive (Chan 2006) because:

- It is renewable and has the potential to significantly reduce or slow down growth of carbon emission (Basri and Chan, 2008).
- The biomass in capturing carbon from the air and subsequently releasing it when generating energy is simply returning carbon to the air to complete the cycle.
- The key motivation in the development of bio-energy is the possibility of displacing large use of fossil fuels.
- Given the bulkiness and weight of biomass feedstock it necessitates that the location, collection and conversion facilities be set up close to the plantations.
- The construction of such bio-energy infrastructure will generate extra economic activity in rural areas.

Thus implementation of bio-energy together with food production from oil palm plantations has multiplier effects on:

i) the fight to eradicate rural poverty,
ii) improve food security,
iii) ensuring sustainable use of local resources to generate energy
iv) adding energy service portfolio by linking excess energy generated to national grid thereby enhancing the rural community's ability to develop new economic activities in an integrated manner around the palm oil mills
v) further as a stimulant to economic growth that was first identified soon after the announcement of the palm oil biodiesel policy in August 2005 but has not seriously taken off.

Now with the energy crisis, it is opportune to explore its full potential in the following seven focus areas.

Focus Areas:

1. Production Increases through Crop Breeding and Biotechnology

1.1. The Oil Demand: The world requires palm oil to feed her growing population. Rising world fuel prices, growing demand for energy, concerns for global warming are key considerations driving the increase in use of palm oil as food and residues as RE but their interactions between demands on the crop for bio-energy feedstock and for production for food deserve attention. All along there has always been a steady increase demand for oils and fats, as shown in Table 1, and looking at the production and disappearance figures, there is barely any excess available to be converted to biofuel.

Table 1: Global Demand for Oils and Fats for Human Consumption

Total Oil demand ('000t)	2000	2003	2007
Opening Stock	14,652	14,850	17,176
Production	114,757	125,622	154,107
Imports	35,682	44,027	58,381
Exports	35,934	44,282	57,906
Disappearance	113,432	125,841	154,834
Closing Stocks	15,724	14,376	16,924

(Source: MPOB 2008)

Based on the demand for oils and fats in Table 1, the challenge is look at where and what type of oil and fats are available at site-specific countries or locations to be tapped for bio-energy production bearing in mind that world production of oils and fats can barely keep pace with the consumption.

1.2. Production: As an aggressive biofuel growth scenario has been projected by EU where it intends to replace 10% fossil fuel with biofuel by 2010, 15% by 2015 and 20% by 2020, there is a need to look at both the production as well as the export of the types of oils and fats. Only producers that have excesses to meet the food demand first will be in a position to consider going into biofuel production. Table 2 shows the production while Table 3 shows the export of oils and fats.

Table 2: Oils and Fats Production by the 17 Oils and Fats

Global Oils and Fats in ('000t)	2000	2003	2007
Palm oil	21,867	28,259	38,246
Palm kernel oil	2,698	3,347	4,397
Soya bean oil	25,563	31,241	37,481
Cotton seed oil	3,850	3,987	5,119
Ground nut oil	4,539	4.568	4,156
Sunflower seed oil	9,745	8,917	10,997
Rapeseed oil	14,502	12,698	18,521
Corn oil	1,966	2,017	2,337
Coconut oil	3,261	3,270	3,033
Olive oil	2,540	2,904	2,993
Others (Castor, Sesame, Linseed)	1,907	1,892	2,094
Total Vegetable oils	92,438	98,368	129,374
Total animal oils	22,319	22,645	24,733
Grand total	114,757	125,622	154,107

(*Source: MPOB 2008)*

From Table 2 the biggest type of producers with over 10 million t production of oils and fats in excess are the palm (38,246 million t CPO plus 4,397 million t kernel oil totalling 42,643 million t), soya bean (37,381 million t), rapeseed (18,521 million t) and sunflower (10,997 million t).

Table 3: Global Export of Major Oils and Fats

Export of Major Oils and Fats ('000t)	2000	2003	2007
Palm oil	15,019	21,911	29,694
Palm kernel oil	1,220	1,788	2,574
Soya bean oil	6,771	9,327	11,197
Sunflower oil	3.054	2,593	4,162
Rapeseed oil	1,783	997	2,162
Coconut oil	2,046	2,306	1,889
Other Vegetable oils	2,118	1,730	4,178
Tallow	2,215	2,115	2,286
Other animal fats	1,709	1,515	1,664
Total	35,934	44,282	57,906

(Source: MPOB 2008)

However from Table 3, it is observed that only two oils in 2007, palm (29,264 million t CPO plus 2,574 million t kernel oil totalling 32,268 million t) and soya bean (11,197 million t) have the potential to export their excess production to meet world food demand.

1.3. Global export of major oils and Fats: Of the 17 oils and fats, only palm and soya bean therefore, and perhaps some sunflower and rapeseed oils, have the potential to be converted to biodiesel. Among the oil palm producers, the main potential exporters of palm oil for conversion to biodiesel are Malaysia and Indonesia as shown in Table 4.

Table 4: World Major Exporters of Palm Oil ('000t)

Country	2000	2003	2007
Malaysia	9,081	12,266	13,738
Indonesia	4,139	7,370	12,530
Others	1,798	2,272	3,430
Total	15,019	21,911	29,694

(Source: MPOB 2008)

As stated in the Principle 1, palm oil is used mainly as food and any attempt made to make large quantity of palm oil as a feedstock for bio-energy must concentrate on technologies to produce second-generation biofuels where the cellulosic conversion technologies through aggressive R&D should be available by 2015. The challenge in moving away from the use of palm oil is to avoid the "food versus fuel" issue. By 2015, hopefully Malaysian B5 blending would have progressed well to be a steady industry on its own and the amount of excess palm oil mopped up for conversion, estimated to be 500,000t, is done through trans-esterification process to biodiesel and this volume converted should be held constant to keep the emerging biofuel industry going. There should not be too much siphoning of palm oil, as shown in Table 4, for fuel conversion. By then there will be a rise in the production from second-generation technologies of fermentation of bio-ethanol and pyrolysis to bio-oil, syn gas and char carbon through the conversion of the non-food biomass from oil palm crop residues as shown in Table 5.

Table 5: Biomass available from the Mills in 2007

Type of Biomass	Ratio to FFB	Biomass from 80 million t FFB Processed
1. POME	65	52.0
2. EFB	23	18.4
3. Fibre	13	10.4
4. Shell	6	4.8
Total		85.6

(Source: Ravi Menon, 2008)

In order to better support the expansion of feedstock supply in response to the growth in demand of bio-energy with the use of second-generation biofuel technologies, the challenge is to invest aggressively into R&D to take advantages of the calorific value in the oil palm biomass as shown in Table 6 by looking at R&D of energy efficiency technologies.

The R&D should explore the ways the biomass is utilised as follows:

i) raise the productivity of the production of palm oil in the field,
ii) conversion efficiency of the biomass into biofuels in the bio-refinery,
iii) look at improving the energy efficiency (EE) in the mills and
iv) trapping the methane by retrofitting geo-propylene cover over the ponds or
v) using inverted concrete cylinders with moving roofs to digest the effluent.

Table 6: Calorific values of biomass in oil palm plantations

Type of Biomass	Calorific Value (KJ/Kg Dry)
CPO	39,380
Trunk	17,471
Frond	15,751
Palm oil mill effluent	16,992
Root	15,548
Empty fruit bunches	18.795
Fibre	19,055
Shell	20,093
Kernel cake	18,884

(Source: Ravi Menon 2008)

1.4. The role of Biotechnology: From the point of use of second-generation conversion technologies, R&D through the use of biotechnology is to reduce the lignin content in crop biomass so as to improve bio-refinery efficiencies in the extraction of bio-ethanol. Disciplines such as genomics, proteomics and metabolomics are being used to improve our understanding of and our ability to manipulate lignin biosynthesis pathway. Care must also be exercised that the loss of lignin content may not lead to palms with lower disease resistance or a lack wood strength on the fibre for furniture manufacture.

1.5. Economic and social benefits: The potential economic and social benefits of modernising the Malaysian biomass energy industry would come from the fact that agricultural production of palm oil as food hitherto also produces a lot of biomass residues which now can be used as feedstock for biofuels production. It is good to bear in mind that bio-energy is considered to be a carbon-neutral source of energy and could therefore do much to help in reducing carbon emissions. It now requires a new set of investments for the oil palm industry to produce second-generation biofuels and document the evidence that through the life-cycle approach that there will be carbon and energy savings when compared with fossil fuels carbon emissions. By then it certainly will be in a position to help reduce the daily world consumption of 21 million barrels of fossil gasoline and another 21 million barrels of diesel.

Therefore the key benefits of developing the bio-energy aspect are:

- Firstly to move away from use of palm oil as biodiesel using first-generation technology initially
- Secondly, with second-generation biofuels technologies help the country to have a mix energy portfolio that diversifies the energy sources, and
- Thirdly, to commence a small but gradual replacement of the use of fossil fuels like diesel with local consumption of biofuel B5 blend.

With this bio-energy roadmap, the industry can then start to make new inroads by contributions to:

i) eradicating rural poverty
ii) step up R&D into the use of second-generation biofuel,
iii) improving the food security situation in the country when second-generation biofuel feedstock and technologies currently in the pipeline are expected to provide promise not to interfere with the palm oil supply and to bring about much improvement to overcome the food versus fuel issue, and
iv) demonstrating that sequestration of carbon by the oil palm crop is more than any other the alternate land use by emphasising that the more carbon is retained in the roots in the soil on a long-term basis after each planting of 25 years through zero tillage at every replanting.

Bio-energy, though uses resources such as land, water and labour, has the potential to address one further challenge of producing other fine bio-chemicals from the palm biomass since over 90% of its biomass has yet to be fully exploited. However for this to be developed, many policy measures will first have to be put in place.

2. Avoiding 'Food Versus Fuel' Issue by Meeting EU Biofuel Directive Demands

2.1. First –generation versus second-generation biofuel conversion technologies: As alluded to in **section 1.3,** we must move away from over reliance on first–generation technology to convert palm oil to biodiesel. Presently the demand for first generation biofuel like palm biodiesel is high yet the infrastructure to do the transesterification process is now just coming into place. The government has just announced a RM200 million allocation to help build infrastructure for biofuel production (Kingsman 2008c).

Second-generation technologies of fermentation and pyrolysis will open further development in cost-effective conversion of cellulosic–rich biomass to bioethanol and bio-oil, syngas and char carbon. The two major pathways are:

i) Thermo-chemical processes of gasification and pyrolysis involving the thermal decomposition of biomass at high temperatures to generate gaseous (syngas) or liquid (bio-oil) fuels that can be used to fuel power plants, for cooking or as transport fuels. The char can be applied back to the fields to maintain soil carbon.
ii) Biochemical conversion with enzymes where during the fermentation process the cellulose is converted to sugars to bio-ethanol.

2.2. Food Versus Fuel: Serious consideration should be given to the second-generation cellulosic conversion technologies where:

- Investment of R&D into cellulosic conversion technologies are assumed to come on stream by 2015
- There will be a relaxation on the food-based feedstock such as palm oil but there must be a level for the off take of palm oil, currently at 500,000t to support the B5 blend
- As to the amount of biomass that could be used for second generation biofuel conversion, there must be a cut off point on the use of biomass.
- Currently a 50% use of biomass is diverted based on the requirements for mulch and nutrient substitution to maintain soil fertility in the fields.
- Result: The scenario underlies the importance of R&D and the focus underlines the potential of such technical innovations from cellulosic conversion technologies.

3. R&D Requirements on Second Generation Biofuel from Biomass Feedstock

3.1. Research and Development: We need to explore some of the technology options and research priorities in the future on second-generation feedstock and conversion technologies on biomass to bring about large improvement on the carbon balance through:

- Aggressive growth of biofuel sector with crop productivity increase
- This is an opportunity to be tapped by working to meet the big demand of biofuel in EU by taking into the consideration of its projected targets of 10% renewable by 2010, 15% by 2015 and 20% by 2020.
- The breakthrough in biofuel technologies, expected to be out by 2015, will support expansion of biofuel to meet the demand growth
- Result: There would be increase in price of palm oil when year-end stock is low and the same time in biofuel (B5) would provide the local demand for biofuel.

3.2. Renewable energy: Given EU's high important demand for biofuel and its commitments to reduce CO_2 emissions under Kyoto Protocol, political pressure is put to bear to implement strategies for use of RE to be ever increasing. It is expected that EU will aspire to use substantially more RE biofuel than it currently produces. The extra will be met by import. Therefore R&D will have to study and find the right balance between supporting a domestic biofuels programme and adopting a more economically efficient approach of exporting biofuels is required.

3.3. Energy efficiency: Another area is to do R&D in making technological improvement in the EE in conversion of the biomass so as to release the balance of the biomass from the mill for other economic uses besides being combusted for supply of combined heat and power (CHP)

3.4 Trapping of biogas: In retrofitted effluent ponds or in specially designed moving rooftop in inverted concrete cylinders, the biogas from digestion that is trapped can be used through gas turbines to generate energy for the mills thereby freely more fibre and shell for other agricultural use or for medium density fibre board manufacturing. Alternatively R&D is done to connect the extra energy to fit into the national electricity grid supply. Further discussion with TNB (Tenaga Nasional Berhad) and other stakeholders is required.

4. Mitigating Climate Change through UNFCCC's KP CDM projects

Agriculture is already mitigating climate change through the increase of growing of crops and plantation trees. This is because crops and trees naturally sequestrate carbon as part of plant growth. The biomass residues when used as a source of bio-energy will help substitute fossil fuel use. The size of GHG emissions reduction will depend on the net energy and carbon balance that the simultaneous production of the crop and biomass yields. Further, there is also the type of agricultural practices like leaving soil undisturbed during replanting would mean that carbon from roots would remain in the soil. Therefore agriculture when combined with afforestation and reforestation the cultivation of forest plantations becomes a long-term means of cost-effective carbon sequestration. Planting perennial tree crops like oil palm and also rubber is a more economical form of carbon sequestration.

4.1. Land Use and Environmental Impacts: Growing bio-energy crop like oil palm requires fossil fuels for production, harvest, transport and processing the feedstock into biofuel and also for refining and distributing the biofuel. Depending on the yield of feedstock and on where and how it is grown and used, the net carbon balance can vary widely. Net carbon and energy savings must be quantified and measured so as to be assured that even the current first-generation feedstock of palm oil converted by trans-esterification technologies to biodiesel have carbon balances that are better than that of fossil oil.

4.2. The Larger Carbon Context: As awareness and concerns about climate change, food and energy security rise, a few universal truths may be drawn about the environmental effects on planting of oil palm. In the process of producing food and biomass, the oil palm plantation system which is ideally suited to the Malaysian edaphic conditions by contributing to improving the environment by revegetation of the land. In fact much of the R&D effort in the past was devoted to investigate how different soils can be managed to support the growth of oil palm. Thus, besides the bulk of the inland soils, coastal soils, marine clays, saline soils, marginal soils, calcareous soil, acid sulphate soils and even peat land soils were found to support oil palm crop successfully, thanks to the agronomic research into cultivation and production. Besides yield, other benefits include quantity of sequestered carbon, protection of watersheds through the use of riparian strips, provision of habitat for local and migratory species of birds and contribution to improving the livelihood of the rural communities. As an agricultural pursuit, oil palm plantations generally provide a net improvement on food and bio-energy production depending on how they are generated.

4.3. Food, Bio-energy and Carbon Balance: Though food and biomass production is considered as "renewable" source of energy for human and engines respectively, the resultant biomass typically involves the consumption of fossil fuels for other operations that must be quantified. It includes the fuels consumed by farm machinery for land preparation, planting, application of chemical inputs like fertilisers and pesticides, harvesting, transport of produce, processing into food and biofuels. Despite this, invariability the oil palm has a higher energy ratio than corresponding oilseed crops as shown in Table 7.

Table 7: Energy ratios of oil palm in comparison with some oilseed crops.

Crops	Energy input (GJ/ha)	Energy output (GJ/ha)	Output/input
Oil palm	19	182	9.6
Rapeseed	23	70	3.0
Soya bean	20	50	2.5

(Source: Wood and Corley, 1991)

The energy ratio is higher in oil palm because of the higher yield and less energy-intensive best practices like recycling of biomass for mulching, growing of legume ground covers, use if Integrated Pest Management (IPM), use of barn owls, predators and beneficial plants. Therefore in deciding whether a crop like oil palm should be considered as a potential bio-energy resource crop, its energy ratio should be used as an indicator because some oil crops in developed countries, for example, having low energy ratio should have second thoughts on using them. Based on the results in Table 7, oil palm is a better candidate to be used a bio-energy resource crop to reduce net carbon emission.

The estimates by Wood and Corley (1991) quoted here probably used production energy figures say from nitrogen utilising old energy requirements derived by the source data of Mudahar and Hignett (1987a and b) dating back to the 1980s. New technologies in oil palm cultivation, packaging, and transport and more efficient fertiliser application practices in oil palm estates all help to reduce the amount of energy used and GHG emitted. The new figures are being compiled in the present LCA study over the whole life cycle of the full supply chain to show an even better energy ratio.

4.4. Carbon Emissions: While a comprehensive update on energy balance and environmental emissions being compiled, it must be borne in mind that bio-energy emissions can affect net carbon emissions in two ways either by providing energy that can replace fossil fuel energy or by increasing higher amount of carbon sequestered on land. The latter is shown in Table 8.

Table 8: Biomass pools and carbon cycling on a coastal plantation 9-10 years after planting

Plant parts	Net dry matter production (t/ha/yr)
Shoot biomass increment	7.05
Root biomass increment	1.23
Litter biomass increment	9.00
FFB Production (Non- oil equivalent)	24.42
Root turnover	2.27
Total	43.97

(Source: Henson, 1999)

To assess the net impact of displacing fossil fuels, the relative carbon intensity must be compared on the basis of emissions associated with the food and biofuel crop production with proper allocation based on quantity and energy to palm oil as food and biomass as bio-energy.

Such an assessment of the net impact of increasing higher amount of carbon sequestered on lands that are ex-secondary jungle or degraded forest has lower carbon say at 65tC/ha instead of the 250tC/ha in pristine forests when cleared and planted with oil palm and harvested sustainably up until the palm is 25 years. The initial carbon sequestered in logged-over forest of 65tC/ha should then be divided by the number of years the oil palm crop is planted, harvested and replanted in cycles of 25 years. As biomass both in the above- and below-ground is accumulated over a 25 year cycle and replanting and harvesting are done on palms in various cycles of say up to 4 or a 100 years growing on the same land goes to show that the planting is really sustainable, then the original 65tC/ha is divided over 100 years and is equivalent to 0.65tC/ha thereby indicating that the net carbon benefit is much higher.

4.5. The Comprehensive Address of Carbon: Under the present Kyoto Protocol (KP) arrangement, the certified emission reduction (CER) units from CDM projects hosted by the developing countries but financed by developed countries, can be counted towards satisfying an Annex I Party's obligation to reduce aggregate emissions during the first commitment period 2008-2012 with any excess carbon credits sold or traded to other Annex I Parties. Currently most of the CDM projects in the oil palm industry involve improvement of EE and use of residues from crop production to generate energy. For an individual field of 30ha, the KP issued temporary CER (tCERs) for the period the palms are in production prior to replanting. On an ecosystem approach, the whole estate of say 5000-8000ha is granted long-term CERs (lCERs) and the whole estate is sequestering carbon.

As 90% of the Malaysian palm oil is used for food with the remaining 10% for non-food use such as oleo-chemicals including biofuel, the whole palm oil production and its co-products are subject to the assessment of the net GHG emissions using the life-cycle inventory analysis (LCIA) framework to track the carbon footprint of the products which include the best management practices on Land Use and Land-use Change and forestry (LULUCF) as well as reduced energy use either directly from fossil fuel usage or indirectly from fossil fuel derived products like fertilisers, pesticides and chemicals thereby demonstrating the structural change towards less resource intensive strategy. However agricultural land-use change is not eligible for CDM in the first period of commitment 2008-2012. The CDM mechanism also does not include afforesation and reforestation given the long gestation period of plantation and the short period of the first commitment period from 2008-2012. Likewise improvement in forest management and forest preservation to conserve biodiversity are also not given financial incentives.

4.6 The Post-2012 Negotiation for recognition of agriculture as economical ways to reduce GHG emissions: Since the Bali Roadmap was spelt out in December 2007, the details of land-use change and practices must make carbon sinks or sequestration a major focus. There are two years for negotiation starting in Posnah, Poland in December 2008 and finalising in Copenhagen in December 2009. This is because carbon sinks based land use practice could offset a large share of carbon emissions and is economical. While afforestation and reforestation are to be retained, there should be better definition of the forests as oil palm plantations have a big role to play in “Avoided Deforestation” (AD) and the “Reduced Emissions from Degradation and Deforestation” (REDD). Plantation forests with oil palm are complex areas not only of avoiding new emissions but also to slow down of climate change by cutting down less forests to plant the oilseed crops to produce the quantity of oil required to feed the growing population. The areas planted are shown in Table 9.

Table 9: Comparison of area planted with different oilseeds compared with oil palm

Oil Crop	Area Planted (10^6ha)	Average oil yield (t/ha/yr)	Production (10^6t)
Oil palm	9.17	3.68	33.73
Soya bean	0.36	92.10	33.58
Rapeseed	0.59	27.30	16.21
Sunflower	0.42	22.90	9.66

(*Source: Oil World 2008*)

The oil palm has the lowest area planted yet produced as much oil as the soya bean which occupied about 10 times the area. Who then is cutting down more forest and who then is destroying more biodiversity habitats? Therefore the plantation forests operators like the oil palm planters must negotiate with the drafters of the legislation, policy, politics, science and law at Posnah and Copenhagen to be creative to seize the opportunities to address the high profile of environment management. The methodologies for assessing bio-energy need to be simplified so that more biomass technologies become eligible for funding. The demands and challenges of our time with the social, economic and environmental concerns in mind especially of high biodiversity areas and land with high carbon stock like peatland as spelt out in the EU biofuel sustainability criteria must be integrated into the plantation forestry’s inventories and social equity. When peat is used, it is the net emission that should be quantified and not just lumping the whole peat as emissions to the oil palm LCA GHG calculation. Using this approach, the oil palm industry will do well to reduce GHG emissions by earning carbon credits for trading and at the same time do good by helping to slow down climate change. There will also be more benefits to sustainable development in the developing countries.

4.7. Finding Common Ground: There are ways in which carbon payments schemes might be introduced to promote bio-energy production and the aggressive growth of biofuel sector with crop productivity increase in the following areas:

- The second generation biomass conversion to biofuel technologies are in place and the crop technologies must now be accompanied by increased productivity to support expansion of feedstock supply in response to growth of biofuel demand
- Sound agricultural investment policies must be in place to develop the twin agricultural economies of food and fuel
- Result: This is the most plausible scenario to mitigate consumer demand and both local government and biofuel producers would just want to mop up the excess palm oil and biomass so as to ensure reliable supply of palm oil for food while supply of feedstock would not diminish the soil fertility and thus erode the competitiveness of the palm oil industry. Further the potential threat of “food versus fuel” is largely absent in this scenario.

5. Sustainability Certification through COA, CoP and RSPO

5.1. Sustainability: Beyond GHG emissions reduction, plantations venturing into food and bio-energy production will present their own local environmental challenges for soil, water and biodiversity management through:

- The Certificate of Assurance (COA) that the palms are planted on genuine agricultural land so the bio-energy production can achieve the best environmental and social outcomes to ensure sustainability of the industry. As 40% of the Malaysian palm oil growers are small holders that include organised groups like FELDA, FELCRA and RISDA and independent farmers, the COA is awarded to all growers who are licensed, registered and regulated with the Malaysian Palm Oil Board. The scheme is to assure their clients that their palm oil is obtained from oil palm planted on legal agricultural land (Yusof *et al.,* 2008).
- The MPOB Code of Practices (CoP), launched by the Minister of Plantation Industry and Commodities on 26 August 2007 covers the whole supply chain from nurseries, plantations, mills, refineries, kernel crushers, and transporter and storage.
- The Roundtable Sustainable Palm Oil (RSPO) certification which now must concentrate on quantifying their GHG emissions after being certified to the 8 principles and 39 criteria covering the whole supply chain of the oil palm industry and include members from the producers, processors, investors, environmental NGOs and Social NGOs. United plantations Berhad became the first group to be awarded the RSPO certificate in august 2008. As of November 2008, the first shipment of RSPO certified oil was delivered to EU market via Rotterdam and RSPO expects 1.5 million t of certified palm oil will reach the market in 2009 (Sustainable Business.com 2008). The arrival of the first certified palm oil shipment in Europe opens up possibilities for palm oil users to move away from subsidising forest destruction and social disruption from expanding oil palm plantation (WWF News Centre, 2008). Consumers now have the means to buy responsibly.

Finally, what this whole certification of sustainability means is that you are as green as your supply chain. Therefore making a strategic transition from doing a traditional business to a green business is full of challenges. We have to examine the worldwide supply chain in order to enhance and ensure that our business and the products are really sustainable through a holistic approach to design, raw material production, processing methods, packaging, shipping, recycling and marketing across the entire value chain. Further what policies, technologies and investment are needed to ensure the twin role of food and bio-energy production is economically efficient as well as compatible in reducing poverty, GHG emission and global warming?

6. Diversification of Crop and Livestock Integration to Cut Down Food Miles

6.1. Intercropping and integration: The successful livestock and crop integration in oil palm plantation is to raise the productivity of the land without opening new land. The use of double avenues planting will allow crops to be successfully inter-planted without another shading of these intercrops by the oil palm canopy. Likewise the successful integration of livestock, especially cattle, is dependent on several key success factors:

- Selection of suitable breed

- Well coordinated management cycles for rotational grazing
- Harmonisation with estate operations like keep cattle away in field that are being spray with herbicides
- Stocking rate depending on grass availability

The benefits besides getting extra revenue through sales of livestock and products from intercropping include reduced weeding cost in integrated livestock fields and with no long-term adverse effects on oil palm yield. However there is an area that needs to be addressed in the emission of greenhouse gases. The cattle methane from enteric fermentation and the handling of manure which fermented will also generate methane. In integrated farming the carbon sequestered per ha was 0.32t C/ha/yr (Pretty *et al.,* 2006).

6.2. Food Miles reduction: The distance food travels from where it is grown or raised to where it is ultimately purchased by the customers or end user is called the food miles. Local food systems like livestock and reduce food miles and transportation costs, offering significant energy saving. Consumers also benefit from fresher, better tasting, and more nutritious food while more food dollars stay within the rural community and the country.

7. Policy Needs to Deliver low GHG Food and Bio-energy for Greater Benefits

With the advances into second-generation bio-energy technologies, there will be a steady expansion of returns per ha. Biofuels present agriculture and rural areas with long-term opportunity in which demand of bio-energy could actually outstrip the growth in supply and therefore generate resources through the optimise use of biomass feedstock to increase income and capital in rural areas. There are several ways to enhance the production of food and bio-energy. They are:

- Oil palm should be used as an energy crop as it yields a higher energy/ha than other oil seeds and therefore should be the preferred dedicated energy crop.
- Oil palm food and feedstock production has even greater potential for energy and emission savings when second-generation technologies come on stream.
- By focusing on the co-products like non-food biomass generated from the same crop where the GHG emissions have been accounted for is essential and what is needed is the proper allocation of the GHG emissions to the various products based on quantity and energy content.
- The rural farmers always benefit from the growing of oil palm because of the economy of scale in growth and processing of both oil for food and biomass for bio-energy; and developing and growing biomass as feedstock for harvest in smaller land as in the case of the smallholders so as to avoid further deforestation of pristine forests is recommended to increase small holders' income.
- The biomass from the small holdings can be organised and fed to more centralised processing plants so that the energy produced can first benefit the smallholders themselves before the excess is transmitted through the national grids so that the country can benefit from the renewable energy from the oil palm crop with favourable energy and carbon balances in contrast with biofuels produced from other oilseeds that have lower amount of biomass feedstock.

- Globally oil palm cultivation in using the smaller total land area which is about 10 times less than soya bean crop to produce about the same oil yield demonstrates the strength of oil palm productivity.
- Palm biomass-based industries are also a significant source of jobs in rural areas.
- Remove barriers to international trade in biofuels is recommended especially at this initial stage of bio-energy development because trade is a powerful way of spreading the benefits of the global capacity of palm oil to grow food and feedstock simultaneously, cost-effectively and competitively in reducing GHG emissions.

Discussion

The oil palm proves that it can have the capacity to provide a cost-effective production of energy to replace some fossil fuels and generate electricity to be fed into the national grid. Producing food and bio-energy offers a challenging attractive alternative for developing countries that grow oil palm where for too long the biomass has been neglected while the palm oil and kernel demanded all our attention. Thanks to the initial assessment the combined production further benefits could be tapped as a food and bio-energy resources due to their favourable energy and carbon balances. The full potential is yet to be harnessed and what is needed is the stepping up of the cooperation to another level between the existing private and public sectors working as partners and making long-term commitments and investments in innovations of a crop that is most likely to yield more cost-effective alternative as a reliable source of bio-energy.

While improvements are being made in the environmental performance of the existing supply of food and biofuels, many of the technologies and production at the early stage of development need to be nurtured. With the building on the progress that is occurring in the understanding of the biological, thermal and chemical systems, the new knowledge will eventually support a wide diversity of opportunities. The diversity of options will prevent a simple focus on a narrow set of production and conversion pathways. An integrated approach is therefore needed which deals with food and biofuel developments. A new carbon reporting and sustainability certification schemes on carbon footprint is being developed by ISO under the new standard ISO 14067 which allows an overall comparison and the metrics to compare individual options that have reduction of the impact on climate change (Chan, 2008).

In the interim, there is an urgent need to optimise the use of the existing biomass feedstock for energy generation without sacrificing the use of biomass such as mulch in the field to maintain soil fertility. An adequate revenue-sharing regulatory and policy framework must be put in place for all the FFB producers who supply the FFB and smallholders included. There must also be capacity building to enable the technical, regulatory and policy expertise be promoted among all stakeholders so that an equitable food and biomass feedstock energy industry can be developed and nurtured. Plantations can become a sustainable dedicated energy centres that help the country to improve their food and energy security.

Conclusion

The oil palm industry must nurture and participate beneficially in the growth of renewable bio-energy and still maintain adequate levels of food security. For this to expand in the future, a complementary set of investments into large scale use of cellulosic conversion technologies for biofuel production and its research is needed. There must necessary be productivity improvement in the oil palm crop and at the same time aggressive growth of biofuel within the country. With such investments, the oil palm industry is likely to produce the benefits for the country and the consumers of both food and bio-energy while contributing to the broader growth of the economy and the betterment of human well-being.

Acknowledgement

The authors are grateful to the Malaysian Palm Oil Board for the permission to publish the paper.

References

Bernama, (2008). RM200 Million Govt allocation for oil palm replanting. Bernama 30/10/2008.

Business Times (2008) Palm oil sector could gain from lifting of fertiliser duty. Reuters 05/11/2008.

Basri, M.W and Chan, K.W. (2008). Oil palm industries' initiatives in mitigating global warming. Paper presented at the 6th Eurolipid Conference at Athens Greece held from 7-10 September 2008. 25pp.

Chan, K.W. (2006). Bioenergy and Palm Oil industry response to climate change. In The Bridge Malaysian Canada Business Council Magazine March Issue 2006, 6-7.

Chan, K.W. (2008). Climate change and carbon footprint impact n the sustainability of the oil palm industry. Paper to be presented at the2008 National Milling Seminar on "Palm Oil Milling Refining Technology, Quality and Environment" held on 15-16 December 2008 at Magellan Sutera Harbour Resort, Kota Kinabalu, Sabah, Malaysia.12pp.

De La Torre Ugarte, D (2006) Developing Bioenergy: Economic and social issues. Focus 14 Brief Vision 2020 for Food, Agriculture and the Environment, International Food Policy Research Institute, USA 2pp

Hazell, P and Pachauri, R.K. (2006) Bio-energy and Agriculture: An Overview. Focus 14 Brief Vision 2020 for Food, Agriculture and the Environment, International Food Policy Research Institute, USA 2pp.

Henson, I.E (1999). Comparative ecophysiology of oil palm and the tropical rain forest. In Gurmit, S; Lim, K.H; Teo L; and David Lee, K (Editors) Oil Palm and the Environment Published by Malaysian Oil Palm Growers' Council, November 1999. 9-39

Hindu Business, (2008). Palm oil import defaults: Indonesia suppliers to seek Indian Govt help. Hindu Business line 02/11/2008.

Kingsman (2008a). Malaysia – Demand for processing plants. www.kingsman.com 24/10/2008.

Kingsman (2008b). Malaysia – 5% blending from Feb. www.kingsman.com 31/10/2008.

Kingsman (2008c). Malaysia- Fund for bio-diesel infrastructure. www.kingsman.com 7/11/2008.

Mudahar, M.S and Hignett, T.P (1987a). Fertiliser and energy use. In Helsel, Z.R. (editor) Energy in plant nutrition and pest control. New York, N.Y. Elsevier Publishing Co.; 1-23

Mudahar, M.S and Hignett, T.P (1987b). Energy requirements, technology and resources in the fertilisers sector. In Helsel, Z.R. (editor) Energy in plant nutrition and pest control. New York, N.Y. Elsevier Publishing Co,; 25-59.

News Straits Times, (2008). ACCIM calls for reduction of CPO stock. NST online 30/10/2008.

Oil World (2008). No 21. Vol. 51. 261.

Pretty, J. N; Noble, I.R; Bossio, D; Dixon, J; Hine, R.E; Penny, De Vries W.I and Morrison, I.L (2006). Policy analysis. *Environmental Science and Technol.,* 40(4):1114-1116.

Sustainable Business.com (2008). First certified palm oil goes to market. 12/11/2008.

The Edge (2008). Malaysia –Palm oil tumbles. The Edge Financial Daily 6/11/2008

The Star, (2008). Palm oil contract defaults to rise. The Star online. 31/10/2008.

WWF News Centre (2008). Sustainable shipment opens new palm oil options. 12/11/2008

Wood, B.J and Corley, R.H.V. (1991). The energy balance of oil palm. In PORIM International Oil Palm Conference Kuala Lumpur.

Yusof, B; Basri, M.W and Chan, K.W. (2008) Why doubt Malaysian Oil Palm Sustainability? Paper presented at the 6th Eurolipid Conference at Athens, Greece 7-10 September 2008. 19pp