Oil Palm: The Agricultural Producer of Food, Fibre and Fuel for Global Economy[+]

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ABSTRACT

Oil palm industry has expanded from just an agricultural producer of edible oils and fats to fibre (material) and fuel (energy) as well for the global economy. In producing food, fibre and fuel (the 3Fs), the industry has also identified the enlarged environmental consequences that will now be involved. Arising from this, the science and technology (S&T) for the 3Fs production now falls squarely on the research and development (R&D) undertaken on land-use and land-use cover changes from forestry (LULUCF) with inclusion of the two latter products. Besides the best practices implemented to enhance the economic, environmental and social requirements, any change in the land-use pattern is prioritized with the environmental consequences identified and minimized. The S&T development in itself is not enough and must be applied together with business. It is critical that sustainability and poverty reduction remain the guiding principles for efficient use of resources, harness of intellect, and channel knowledge to benefit the rural poor and marginalized. As more plantation companies develop the potential to produce the 3Fs, there will be greater realization that both the policy and infrastructure support from the government is important. This must be accompanied by higher participation in activities by all the stakeholders over the whole value supply chain that involve the companies, industry and nation at all three levels to strengthen agricultural development to realize this 3Fs objective.

The benefits of this new 3Fs approach are three-fold: firstly, greater promotion of value-addition and accomplishment of accelerated growth of agro-businesses in the food, material (fibre) and energy (fuel) sub-sectors. Secondly, creating more jobs in the rural sector with greater security for a fair standard of living for the smallholders and their families. Thirdly, discourage migration of people to the urban areas as the rural populace is better able to face the challenges coming from the economic liberalization and globalization resulting from more job opportunities created by the plantations and emerging agro-businesses. A total of 10 recommendations for policy refinement to enhance the

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3Fs objective are discussed. They are aimed at achieving food security, fibre and fuel production by focusing on developmental and environmental consequences; continuing sustainable agriculture to improve the economic, social and environmental impacts of the companies in managing the 3Fs objective thereby hastening rural development when these new agro-businesses start to benefit not only the welfare of the people living in and around the plantations but also along the whole value chain.

INTRODUCTION

Sustainable development in any country, developed or developing, requires the people to do the things that nurture mankind's aspirations and provide society's needs while ensuring a safe and viable environment where the very ecological base the people live on and in is protected. Progressive agriculture is basic to sustainable development (Chan *et al.*, 2004). Tree crop-based agricultural production systems all around the world are basically managed by agro-foresters who have developed efficient use of soil, water and air resources to make them enhance the productivity of the crops for the benefit of the environment and its inhabitants.

Efficient agro-forestry cleans up the air by fixing large amounts of CO_2 and gives out O_2, improves the hydrological cycle through the *rain forest effect*, stabilizes the soil through protective and robust root systems, recycles an ample supply leaf litter, and provides a closed canopy that becomes a favourable bio-diverse habitat for many plants and animals. One such agro-forest system is the advanced oil palm plantation system that is highly sustainable in producing 42% of the palm oil export for the world.

The advanced oil palm system in Malaysia, however, did not just happen. It was planned, implemented and managed for over a hundred years. The planters are agro-foresters at their best. They know their basics (Yusof and Chan, 2002). They are well- versed in the best developed practices to use, what improved genetic material to plant, when optimum balanced fertilizers are to be applied, how soils are protected by natural ground covers, what biodiversity to maintain, when integrated pest management is to be introduced, with all these and many more based on good science, technology and engineering with documented evidence. As a result, the oil palm industry has moved to become more sustainable and competitive (Yusof and Chan, 2003), year after year, with the crop ultimately benefiting both the environment and its inhabitants (Bek-Nielsen, 2004; Rao, 2004). The planters are indeed truly the stewards of the earth resources.

Basically in the 21st century, the oil palm industry has three important simultaneous challenges to meet. They are to produce:

- a steady supply of palm oil for food security;
- material for fibre products manufacturing; and
- renewable green fuel by conversion of excess palm oil into biodiesel for the global economy.

The call to the industry to move to the 3Fs has been made earlier (Chan *et al.*, 2004*)* but there was only an outline of what was

involved and this prompted us to look further into the complexity of the 3Fs objective for the industry. It has to move from the production of food (Yusof, 2001), the first *F* that it is doing very well, to fibre material (Yusof, 2002a), the second *F* that has taken off, and now into fuel (Yusof, 2002c), the third *F* that is beginning. The treble Fs (for food-, fibre- and fuel-production) objective requires the industry to re-examine the developmental and environmental impacts of the enlarged extraction of fibre and fuel in addition to food, all of which are taken from the same land to supply the world demand. Agronomically, it is possible to mine the land optimally for the 3Fs, as there are opportunities to produce new uses for food, fibre and fuel (Yusof, 2002b). In other words, without neglecting the world's need of palm oil for food, the industry has also to gear itself towards more value-added products from fibre and fuel if the 3Fs objective is to be fulfilled while preserving agronomic and environmental sustainability within the plantations.

OBJECTIVE OF PAPER

The aim of this paper is to explore ways on how to fulfill the 3Fs objective in the oil palm production system without over exploiting the land on which the oil palm is grown. There are two prior major considerations, *viz*., the developmental and environmental aspects, to be dealt with first.

Developmental and Environmental Aspects of the 3Fs Production Objective

Developmental aspect. In the cultivation of oil palm in the context of 3Fs, the potential expected benefits identified are:

- firstly, enhanced employment opportunities for the people and rural development. There is a multiplier effect that helps to generate more economic activities that would eventually strengthen the local economy, particularly that in the areas where the new industries are spawned. The agro-businesses arising from the 3Fs are a significant source of domestic employment in the form of short- and long-term jobs. They include jobs such as planting, cultivation, harvesting and transport of palm oil as food, fibre material from the biomass, excess palm oil to be used as feedstock for fuel, and the construction and operation of food processing plants, fibre extraction plants for production of material and bioenergy conversion plants for fuel production.

- secondly, in addition to the creation of jobs, there is infrastructure development and this is implemented through extension of the 3Fs services that allow the rural populace, on one hand, to produce more food, fibre and fuel energy in plantations, particularly in their smallholdings, and, on the other hand, for the government agencies and extension teams to do their advisory work. The aim is to raise their income.

- thirdly, as a further benefit of the 3Fs objective, particularly on the third *F*, the oil palm industry, as both an energy producer and user at the same time, must demonstrate that as a result of its energy surplus, it can use the excess energy to enhance fulfillment of the other 2Fs of food security and fibre material production. Very often, even with just a 2Fs objective in other agricultural systems, like soyabean, rapeseed and sunflower seed crops of, say, food and energy production, there are already potential conflicts due to the competition and need for the same limited land to grow either an energy producing crop or cereal. This conflict is however avoided in the case of the oil palm industry. This is because within the oil palm production system, palm oil forming the first *F* is at 10% while there is about 90% of the plant biomass remaining largely untapped and available for the second *F* of fibre material production and also the manufacture of export value-added finished fibre products, and for the third *F* fibre material for combustion to generate *green* energy. Currently, some palm oil is drawn to keep the year-end stock low and convert them to biodiesel which is also a *green* fuel. There is therefore synergy rather than conflict in the 3Fs objective in the oil palm system.

- fourthly, for the excess palm oil stock, particularly at year-end, efforts have begun to convert it to biodiesel, turning it into an agro-energy resource to boost the supply of the third *F* fuel energy for use in food and fibre production and in the transport industry. All these again reflect the strong

synergistic effect of the 3Fs objective within the oil palm industry.

- fifthly, yet another benefit is for the palm oil importing countries to encourage and save the land used for their costly cultivation of oilseeds for the cultivation of other more essential food crops, thereby ensuring food security in the staple crops. As an example, if soyabean or other oilseed crops are assumed to yield 0.5 t ha^{-1} oil, then for every tonne of palm oil imported, the oilseed producing countries can save about 2 ha of land from planting with oilseeds for the more needed cereals.

Thus, the major challenge for the Malaysian palm oil industry is to ensure food security by producing additional food by using the excess fibre or oil, while conserving the depleting resources, particularly land, for fibre and fuel production. This 3Fs objective indeed has a spill-over effect for the palm oil importing countries as they can then use their limited land to focus on the production of a diverse food basket by raising essential grains given that the land is freed from oilseed planting.

Environmental aspect. On the environmental aspect, there are several consequences that need to be addressed if the 3Fs objective is to benefit the industry.

- The first benefit of the 3Fs objective is energy production in which renewable biomass instead of fossil fuel is used. The excess fibre, instead of being recycled to the field as mulch is combusted to generate steam and then energy. More complete combustion by pyrolysis is being investigated. The energy generated is green because oil palm biomass is renewable.

- Secondly, although an oil palm plantation is not able to accumulate as much biomass as a natural forest over its short 25 years of each life, much more carbon is sequestered than by any of the annual oilseed crops of soyabean, rapeseed and sunflower which land has to till every year.

- Thirdly, oil palm effluent ponds are now considered potential profit earners in which the methane produced is harnessed as biogas to replace fossil fuels to further reduce the GHG emissions.

- Fourthly, notwithstanding the above aforementioned benefits, the oil palm is also a cheap means of reducing atmospheric CO_2 through carbon sequestration. As the biomass from the oil palm becomes an important energy source, new opportunities abound for oil palm to be planted at closer spacing for the sole purpose of biomass production. Such opportunities on a larger scale offer the benefit of rehabilitating steep marginal areas and abandoned degraded lands by planting them up as dense agro-forests. In the past, such marginal areas, blamed for low bringing down the national yield, will now consider any yield at all to be a bonus.

- Fifthly, these dense oil palm agro-forests offer another environmental advantage such as biodiversity. The closed canopy will simulate a natural forest where different flora and fauna will flourish to enhance the biodiversity. The agro-forests will clean up the air by absorbing CO_2 and emitting O_2 thereby also creating an oxygen-enriched and healthier environment.

Thus, in a scenario of shrinking resources such as land and water, the challenge is to combine conventional planting to increase the yield of oil palm, yet produce fibre and fuel from the agro-forests to improve the ecology.

ACTUALIZING THE CHALLENGES OF THE 3Fs OBJECTIVE

From the introductory outline of the two prior considerations above, the Malaysian oil palm industry has to explore whether it has the potential to actualize the challenges of the 3Fs objectives of food security, fibre material production and fuel conversion from palm oil.

This potential can be actualized through a combination of policy change and infrastructure support from the government on one hand, and the strengthening of the synergies on the other hand among the various players throughout the whole value supply chain. All players must fulfill their roles over the whole field of agriculture, rural development and mill processing so as to result in the export of quality end-use products from food, fibre and fuel agro-businesses to customers. Basically, the policy change is to strengthen rural infrastructure support by the government for faster agricultural

development, promote value-addition from accelerated agro-business development, create employment in rural areas thereby securing a fair standard of living, and discourage migration to urban areas because the jobs created would allow the rural populace to face the new global challenges arising from economic liberation and globalization better. The 3Fs objectives are discussed separately for food, fibre and fuel production though they are closely interlinked.

Food Security

This will be discussed under three separate headings of how the oil palm industry can contribute to food security:

- understand food security;
- exceed food security requirement; and
- meet the requirement of the three major food types of oils and fats, protein and carbohydrate.

Understanding what food security means to the oil palm industry. Food security is a complex issue. First, it involves food scarcity that affects a number of undernourished people. In 1996, the World Food Summit reported that there were 854 million undernourished people (Stryker and Metzel, 1998) and that over 25 000 people died every day from hunger. In the FAO report (2004), the number of undernourished improved slightly to 815 million in 35 countries of which 777 million were from the developing countries, mainly of 24 countries in Africa. The causes of food scarcity may be from natural disasters (flood, drought) or man-made (famine, war). Food scarcity is generally more of a developing country problem than a developed one as developing countries often lack the mechanisms for food production, storage and distribution.

Second, food security is defined as the availability of enough food to sustain life and good health of all the world population at all times, across all countries and regions, across all income groups and across all members of individual households (Berck and Bigman, 1993). The definition requires policies to take on both economic and political dimensions and involves three categories of factors - getting prices right, optimal storage and supply enhancement.

Third, food security is therefore a physical, environmental, economic and social issue. It involves not just production but access, not output but process, not just technology but policy, not just global balance but national condition, not just national figures but household realities, not just rural but urban consumption and not just quantity but quality.

Finally, the concept of food security covers every individual who has the means to have physical, economic and environmental access to a balanced diet with macro and micro nutrients, drinking water, sanitation, hygiene, health care and education to lead a healthly and productive life.

Thus, the steady production of quality palm oil at a relatively low cost is ready to feed the world (Yusof and Chan 2004a).

How to meet food security requirements by the Malaysian oil palm industry? There are several considerations to reflect Malaysia's superiority in meeting the food security requirements through the oil palm system.

- Firstly, the requirement for a cheap supply of nutritious food. For a nation that depends on food imports annually to feed her population, Malaysia today is more than self sufficient in oils and fats - thanks to the oil palm industry that exports palm oil to over 150 countries. Palm oil from Malaysia as a cheap, reliable and nutritious food fits nicely as a candidate to meet the requirements for developing food security in the importing countries with food scarcity.

- Secondly, a food required for part of the daily diet. Oils and fats are an important food item constituting a regular part of the human diet which is calorie dense. Each gramme of oil and fats provides 9 kilocalories (kcal) of energy as compared with 4 kcal g^{-1} from carbohydrates and proteins. Oils and fats are an essential component of a balanced human diet, and the World Health Organization (WHO) recommends that 30% of the energy (calorie) requirements of an individual should be obtained from oils and fats. This works out to a per capita consumption of about 20-24 kg oils and fats per year. But for most of the world population, these figures are not realized, mainly due to unavailability and affordability. Thus, Yusof *et al.* (2001) considered that food security in oils and fats should be a crucial issue.

- Thirdly, a requirement for a steady supply of palm oil. The progress made by the Malaysian oil palm industry in the production of oils and fats during the past five

decades has been one of the biggest success stories of the country. From a mere 54 000 ha in the early 1960s, it reached 3.87 million hectares in 2004. Malaysian palm oil production and exports in the 1960s were in the region of 90 000 t and by the mid 1970s, palm oil export were in the region of 1.5 million tonnes. By the decades of 1980s, 1990s and 2000s and in 2004, as shown in *Table 1*, palm oil exports reached 2.3, 5.7, 9.1 and 12.6 million tonnes respectively. Thus, palm oil constitutes one of the single largest contributors to the Gross Domestic Product (GDP), earning RM 30.41 billion in 2004 (Palmoil Update, 2005), up from RM 26.23 billion in 2003.

TABLE 1. MALAYSIAN PALM OIL PRODUCTION AND EXPORTS FROM 1980-2004 (t)

Year	Production	Export
1980	2 573 173	2 271 222
1990	6 094 622	5 727 451
2000	10 842 095	9 081 553
2004	13 976 182	12 575 401

Source: MPOB (2005).

- Fourthly, a requirement for protein and carbohydrate besides oils and fats. Despite the impressive gains, Malaysia at present finds itself in a paradoxical situation. On one hand, there is surplus in oils and fats production (vide *Table 2*) with 17.35 million tonnes exported in 2004. On the other, it has to import protein and carbohydrate.

- Fifthly, a requirement for non-religious implication and versatility of the oils and fats in food products. As palm oil is a non-religious food that can be used by Muslim and non-Muslim countries and very versatile due to its unique properties, it is exported to over 150 countries. The four major importing countries in 2004 were China P R, European Union-25, Pakistan and India as shown in *Table 3* where, together, the off take amounted to 53% of Malaysian exports.

TABLE 2. MALAYSIAN EXPORTS IN 2003 AND 2004 (t)

Item	2003	2004
Palm oil	12 266 064	12 575 401
Palm kernel oil	868 658	778 857
Palm kernel cake	1 809 957	1 795 918
Oleochemical products	1 568 239	1 776 441
Finished products	259 472	374 345
Others	48 945	57 277
Total	16 821 334	17 348 239

Source: Palmoil Update (2005).

TABLE 3. EXPORTS OF PALM OIL TO FOUR MAJOR DESTINATIONS IN 2004 (t)

Country	Export (t)
China P R	2 799 702
EU-25	1 967 111
Pakistan	953 772
India	941 863
Rest of the World	5 912 953
Total	12 575 401

Source: Palmoil Update (2005).

Thus, from the aforementioned requirements, though Malaysia has a surplus in oils and fats, she has to tackle and reduce imports in the other two types of food *viz*., protein and carbohydrate. What are the things the oil palm industry can do to reduce or eliminate the imports?

What the oil palm industry can do in reducing imports of protein and carbohydrate? The challenge is met by four strategies.

- Firstly, by strengthening livestock and crop integration. Here, the 3.87 million hectares of oil palm, or 60% of the 6.02 million hectares designated for agriculture under the Third Agricultural Plan (1998-2010), can be used to raise the production of protein and starchy foods. With the limited land available in the Peninsula and lack of human resources like labour throughout the country, the challenge is even more daunting to maintain the production of palm oil and yet raise livestock and food crops. It is important that packaging this challenge for which the growers, who have to bear the cost, will be able to benefit not only from this investment but also that the methodology developed will sustain the welfare and incomes of the workers.

- Secondly, to be in line with the government aspiration for agriculture. Here the approach is to look further into the agricultural productivity of the oil palm industry. Since the Abdullah Administration's return to power in the 2004 general

election with a bigger majority in Parliament, it has decided to revitalize agriculture as the third engine of growth by focusing on its productivity as a whole with an emphasis on raising that of the smallholders. To respond, the industry must examine the agricultural structure in the country that requires long-term solutions. A strategic approach to modernize plantation agriculture is to use the agro-forestry and value-added enhancement concepts.

- Thirdly, the use of the agro-forestry concept. Under the agro-forestry approach, the increasingly depleting resources, such as land and water, would require optimizing the use of land for agriculture and forestry simultaneously. There are obvious benefits:

    1. The aim is to integrate agriculture with forestry as mutually compatible and complementary industries. The integrated approach allows sharing of the land for production of both agricultural and forestry products, thereby mitigating the demand for new arable land. The symbiotic relationship of planting forestry species with industrial crops is to optimize land utilization and maximize returns. During the long gestation period for agro-forestry there are opportunities for intercropping which the private sector is encouraged to participate in.
    2. For this to happen in the oil palm industry, there must be adoption of double planting avenues with more space in between the planting rows for raising cattle and food crops. It is anticipated that about 120 000 ha of oil palm will be replanted annually over the next five years from 2006-2010 (Dayang, 2005). As reported previously by Yusof and Chan (2003), the country had attempted to produce protein through cattle rearing by clearing large tracts of land and planting grasses with cattle as monoculture, but this was found unprofitable compared with oil palm. Likewise production of carbohydrate such as rice is also not as profitable as oil palm. For the local needs, rice is partly imported and its production subsidized. Next, even using agricultural land to produce rubber as an industrial commodity was also found to be less profitable compared to oil palm cultivation, and over the years, substantial areas of rubber have been replaced with oil palm. Though cocoa may be considered a food crop as a beverage, its cultivation was also found to be not as profitable as oil palm and its land replanted to oil palm. With such large planting of oil palm, there is little choice but to delve into livestock/crop integration.
    3. Alternately, the oil palm itself, which is largely unused, should now be exploited as a source of fibre from the field, *e.g.* from the fronds regularly, from the trunks at replanting, and the shell, fibre and empty fruit bunches from the mills. The fibre when converted to medium density fibreboard (MDF) will reduce the exploitation of forests.
    4. When the sums are added up, even though, for example, in 2002 the country imported RM 12 billion of food, it still exported more food products such as palm and palm kernel oils products and cocoa products with a net RM 8 billion of surplus. By being a net exporter of food products, the country is able to import at cheaper prices other food items that the country cannot grow efficiently. This is due to the superior agricultural productivity and profitability of oil palm agriculture. By specializing in plantation agriculture, the country has better technological and economic advantages and by deliberately importing other food items, the country is able to optimize its resources.
    5. Thus, food security is adequately assured if oil palm continues to be

cultivated under integrated agriculture with the land jointly used to produce protein and carbohydrate. Optimizing land use through livestock crop integration (LCI) is gaining ground and today already about 78 estates have embarked on cattle integration. Likewise, crops like hill paddy, sweet corn, maize and water-melon are being integrated. Thus, with greater persistence LCI, the import bills for protein and carbohydrate are expected to drop further.

- Fourthly, a requirement for value-added activities over the whole supply chain. With more protein and carbohydrate being produced, there will be more opportunities for downstream manufacturing and such facilities may have to be expanded to process besides oils and fats from oil palm, also carbohydrates from paddy and food crops, and protein from livestock and fisheries. In this way, the production of value-added downstream products, with the spawning of small food agribusiness units, may be expanded. With implementation of the value chain management, the sub-benefits areas are:

    1. To be competitive, the oil palm industry must continually add value to its core products of palm oil, fibre and fuel, *i.e.*, the 3Fs and services in order to create future security (Yusof, 2002c). To do so, there must be a broad framework of variables that would significantly influence the factors that enhance the competitiveness of the oil palm industry.

    2. Under this enhancing of product-based value-added approach, the aim is to meet the demands of customers worldwide for products that are specific to their needs and preferences. Such value-added products are made accessible through information communication technology (ICT) that supports the customers' ability to seek, identify and procure these products, processes and services. This is a definite shift from the commodity-based strategy that limits the effectiveness to serve the markets that are now becoming to be of higher value and more segmented.

    3. By relating the end-products directly to the primary production, the value-added product-based approach will strengthen the strategic role of upstream agricultural and forestry production with value-adding activities over the whole value supply chain.

    4. The product-based approach allows identification of opportunities for market expansion for agro-based manufacturing and other economic activities.

    5. This will include opportunities for R&D and technology generation, improve primary production, processing, manufacturing of intermediate and final products as well as distributing and marketing of the end-products and services to the consumers.

Fibre Material Production

The oil palm is a prolific producer of biomass, particularly fibre. The material is available throughout the year as empty fruit bunches, fibre and shell in the mill. In the field, during replanting, large quantities of trunk and fronds are also available. The dry weight of biomass fibre available each year is at least twice that of palm oil. When manufactured into MDF or pulp, a tonne of fibre is usually worth more than a tonne of palm oil. The quantity of trunks and fronds at replanting is shown in *Table 4*.

TABLE 4. AMOUNT OF DRY WEIGHT OF TRUNKS AND FRONDS AT REPLANTING IN 2003

Parameter	2003
Total area (10^6 ha)	3.802
Immature (10^6 ha)	0.499
Mature (10^6 ha)	3.303
Rate of replanting (4%)	0. 04
Dry wt of trunk (t ha^{-1})	75.46
Dry wt of frond (t ha^{-1})	14.47
Dry wt of trunk at replanting (10^6 t ha^{-1})	9.155
Dry wt of frond at replanting (10^6 t ha^{-1})	1.755
Dry wt of annual frond pruning (10^6 t ha^{-1})	43.887
Dry wt of annual frond petiole (10^6 t ha^{-1})	14.483

The strategy is as follows:

- firstly, as shown in *Table 4* on a national scale, there are about 14.483 million tonnes of frond petioles available for fibre production. However, in order not to over exploit or mine the land by excessive removal of food, fibre and fuel, the petioles, should only be partly used so as to leave some organic matter in the field to retain soil fertility.

- secondly, the other sources of fibre are the trunk and fronds at replanting, estimated to be 9.155 and 1.755 million tonnes, respectively, but these are spread over 120 000 ha of replant through the country.

- thirdly, go for the fibre from the mills. Normally, the palm and kernel products constitute only 10% of the total harvested biomass, there are great opportunities for the industry to exploit the fibre from the fruit bunches after the oil and kernel have been extracted. Based on the quantity of fresh fruit bunches (FFB) processed in 2004 of 69 million tonnes, there are potentially close to 28.290 million tonnes fibre for extraction from 15.180, 9.315 and 3.795 million tonnes of empty fruit bunches (EFB), fibre and shell, respectively, as shown in *Table 5*.

- fourthly, go for bioenergy in the form of biogas (Yusof, 2005). In the processing of FFB, large quantities of palm oil mill effluent are produced. Though there is no fibre to be extracted, the effluent is a source of potential energy from the methane evolved. The technologies are available to efficiently capture the biogas for heat and energy production. This aspect will be discussed further below.

TABLE 5. EXCESS OF BIOMASS SURPLUS TO MILLS' REQUIREMENT IN 2004 (in million tonnes)

Parameter	2004
FFB processed (10^6 t)	69
EFB @ 22% FFB (10^6 t)	15.180
Fibre @ 13.5% FFB (10^6 t)	9.315
Shell @ 5.5% FFB (10^6 t)	3.795
Effluent	
i) Sterilizer condensate @ 12% FFB	8.280
ii) Clarification sludge @ 50% FFB	34.500
iii) Hydrocyclone washing @ 5% FFB	3.450
Total	46.230

With these potential benefits in mind, the overall material management of fibre, shell and empty bunches from the mill, methane from the effluent ponds, trunk wood chips and pruned fronds from the field has to be reexamined for how they, as outlined in the 3Fs objective, can be used efficiently. To actualize the 3Fs objective, the competing use of the fibre are in the field as mulch, and as value-added products such as ecomats, MDF, *etc*. The contribution to the overall energy management and efficiency for combustion is through the use of more efficient boilers and even through pyrolysis, without affecting the overall productivity of the plantations. This forms the efforts made to realize the second challenge.

Fuel Production

With the increase in awareness and importance attached to global warming, the fibre from the field and mill should be developed as an alternative to fossil fuels. There are two strategies.

Biodiesel production.

- Firstly, a requirement to deal with the high year-end palm oil stock. For biodiesel production from palm oil, the following actions are to be taken:

  1. There is a need to deal with the annual increases in production of palm oil from Malaysia that frequently lead to higher year-end stocks and this invariably results in declining prices even though there is a continuous upsurge in the palm oil export. The year-end stocks in 2003 and 2004 are shown in *Table 6*.

  2. From *Table 6*, it can be seen that among the closing stocks of the four major palm and kernel products in December 2004, what affected the crude palm oil (CPO) price was only the palm oil stock, which at 1.487 million tonnes was up 320 846 t, or 27.5%, over 2003. This temporary increase requires that the excess stocks be reduced by conversion to biofuel to improve the situation for palm oil by a market perception of low stocks. For price stabilization of palm oil, collaboration

TABLE 6. CLOSING STOCKS AT DECEMBER 2003 AND 2004 (t)

Closing stock	2003	2004
Palm oil	1 166 541	1 487 387
Palm kernel	112 398	167 476
Palm kernel oil	169 743	194 934
Palm Kernel cake	238 417	211 979

Source: Palmoil Update (2005).

with the Indonesian palm oil producers may be considered if the programme is to be made more effective.

3. The biodiesel available to be considered for fuel blends.

- Secondly, a requirement to use biodiesel to prolong the petroleum reserves. By the use of palm biodiesel initially for price stabilization, it has opened a new avenue for palm oil as a regular biofuel. MPOB has been the pioneer in researching palm diesel since the 1980s and is planning to build a commercial palm diesel plant in 2006. The palm diesel produced will be used as diesel substitute (by blending with petroleum), mainly for our market. Being renewable, biodiesel has been recognized as an answer to the diminishing petroleum reserves.

- Thirdly, a requirement for biodiesel to be used for running vehicles. Palm biodiesel has been exhaustively evaluated by MPOB as a diesel substitute from 1983-1994. The tests included a large number of vehicles ranging from taxis, trucks, passenger cars and buses with many vehicles having completed the 300 000 km run. The biodiesel technology is now available for commercialization as diesel engines are so widespread all over the world. The various percentages of palm olein in petroleum diesel brand as B2, B5 and B10 to denote 2%, 5%, and 10% palm olein in petroleum diesel B2, B5 and B10 have been evaluated as fuel since 2002. Currently, B5 is proposed for use.

- Fourthly, a requirement for a safety net for the palm oil price. Another benefit of biodiesel production is that it offers a safety net for the Malaysian palm oil industry in times of glut in palm oil production. With the removal of excess stock, the prices can be stabilized. A small removal of half a million tonnes of the year-end stocks should stabilize price of palm oil.

- Finally, a requirement to obtain valuable co-products. The palm diesel project is unique in that its co-product are carotenes (pro-vitamin A) and vitamin E, thereby opening up the nutraceutical and pharmaceutical industries.

Bioenergy from oil palm products.

- Firstly, a requirement to move into bioenergy. Yusof (2005) pointed out that the oil palm industry is in for an exciting time as far as biomass energy production is concerned. Modern bioenergy technologies that can produce electricity, heat and solid, liquid and gas fuels are now available. The strategy is to use renewable bioenergy resources from the oil palm plantation to replace fossil fuels. The biomass of the oil palm consists of the solid fractions of fibre, shell and EFB in the mill, trunk chips and fronds from the field, liquid biofuel from biodiesel and biogas generated from effluent as outlined earlier.

- Secondly, a requirement to have large quantity of biomass for production of bioenergy. For the biomass to be used to meet the 3Fs objective, there must be a better scientific understanding of the process, the potential impact on society and the economic values attached to these impacts.

The total energy potential available from mills in the country is shown in *Table 7*. Based on the surplus biomass available, the total energy potential is about 144.76 10^9 MJ with the largest contribution coming from EFB and the least from fibre, most of which had been used to fire the boilers for the mill operations.

TABLE 7. TOTAL ENERGY POTENTIAL AVAILABLE FROM MILLS

Biomass	Quantity (10^6 t)	Calorific value (MJ kg^{-1})	Moisture level (%)	Total energy potential (10^9 MJ)
EFB	15.180	6.0	65	91.08
Shell	3.795	18.8	10	26.30
Fibre (0.7% EFB)	10.626	10.0	45	4.78
Biogas (14.4 M^3 t^{-1} FFB)	993.6 M^3	22.8	Methane 67% CO_2 33%	22.60

Source: Ravi Menon (2005).

THE 10 RECOMMENDATIONS FOR POLICY REFINEMENT TO ACTUALIZE THE 3Fs OBJECTIVE

The oil palm industry is at a cross-road again. With the global demand for food, fibre and fuel on the rise, there is an imposition on oil palm planters who have to consider the actions to take to sustain their production without degrading the environmental. It must be borne in mind that among the 3Fs only food has advanced well into the supply chain management, but not fibre and fuel. Now, besides food, fibre and fuel would be optimally taken from the same land. Agricultural development centres on the integrated use of natural resources such as soil, water, climate and biological diversity (Chan, 2004) that may be used for the production of the 3Fs. The integration of agricultural practices with management and protection of the ecosystem will promote agricultural productivity and environmental sustainability.

In actualizing the vision of the 3Fs objective, there are 10 recommendations for refinement of the policy:

Ensure Equal Participation at All Four Levels - Company, Industry, Nation and Global

For a start, at the four levels of participation, *viz.*, the local company, industry, nation and global, the players are increasingly being confronted with policies, legal and institutional issues, intellectual property rights, exchange, transfer and trade in agriculture for actualizing the 3Fs objective (Yusof and Chan, 2004b; Yusof, 2003). The participatory processes and involvement of various stakeholders can help, particularly for the latter 2Fs of fibre and fuel production, to find the answers to such concerns, particularly those of developmental and environmental sustainability.

Towards this, it is crucial to develop a framework for a unified programme to enhance the diverse efforts within the four levels to tackle such developmental and environmental issues and make them well understood. Yusof (2003) had indeed provided a firm strategy for global competitiveness for the Malaysian palm oil industry in which the national programmes collectively focus at the increasing competition from future challenges in the international oils and fats market. There are a lot of mutual learning and sharing of information from developmental and environmental issues from the food by the fibre and fuel producers. It is hoped that the fibre and fuel producers will catch up with the current knowledge of the food producers in terms of supply chain management. For the programmes of the 3Fs objective for food, fibre and fuel, they should involve government and its policies, public and private institutions, all plantation companies, the whole industry, NGOs, communities and individuals, especially from the environmental and developmental sectors, and finally from the end users in overseas countries.

Relook at Agriculture and Related Policies

Once the necessary government bodies and institutions are aware of the vision of the 3Fs objective of the oil palm industry, it is crucial to develop and strengthen the monitoring of policies and legislative measures to create an enabling environment for sustainable agriculture and rural development, and environmental sustainability for the oil palm industry along this 3Fs objective. Such an enabling environment will promote the access by smallholders to use their land to start their various agro-businesses involving the 3Fs. It would include activities such as collecting and producing fibre for supply to larger companies that collect it, better use of water resources and agricultural inputs. The enhanced land tenure and taxation incentives for companies to move quickly into these new agro-businesses would be accompanied with better protection for the indigenous knowledge and common intellectual property used in the agro-businesses. There is encouragement for adoption of the resource management systems to ensure that there is no overexploitation of the land now that the 3Fs products are taken out by building local capacities for better management of such natural resources.

The government should consider and introduce new policies and necessary infra-

structure development to expand the activities towards the 3Fs objective. Policies should stress on land reform like rehabilitating steep and degraded land with dense oil palm agro-forests for biomass production rather than FFB yield per se. There must be well-defined enforceable land rights with security of tenure to move into oil palm agro-forests purely to harvest biomass for fibre production. There should also be development of agro-ecological relevant technologies based on the understanding of local conditions and resource management. R&D into oil palm should be balanced to meet the 3Fs objective.

Promote Sustainable Agriculture and Rural Development

Despite the new demand on the land, agriculture as practiced is directly linked to the many facets of sustainable development including poverty eradication, sustainable consumption and production, management of natural resources, energy, fresh water, health, education, trade and market access as well as technology transfer and capacity building. Sustainability should be seen in the context of different agro-climatic zones and the indicators for sustainable development should be identified for actualization of the 3Fs objective.

The R&D effort should be directed to the integration of livestock and crop under oil palm so that food security is assured, yet has the capability to produce fibre and fuel. At the same time, it is critical that the industry continues to develop new technologies and implement them with a business approach to high productivity through the 3Fs objective, environmental sustainability and social development.

Promote Equitable Distribution and Access to Supplies

The challenge to the oil palm industry is to ensure the physical supply of food, fibre and fuel to all importing countries. It is important that production is increased to ensure that food, fibre and eventually fuel in the longer term are available for export to other developing countries through a steady supply with reduced transport cost. At the national level, there should be an emphasis on economic access to the supply for all three food, fibre and fuel to meet the needs for sustainable livelihood and improvement of income of the growers through the multiple income-earning opportunities offered by the 3Fs objective.

Secure Food Security

The issue of food security is related to the whole 3Fs objective. The elimination of hunger and malnutrition is not just a food problem but is related to poverty reduction and the opportunities offered by the 3Fs objective. This would need to look at the increase in productivity throughout the value chain from production, processing, manufacturing, distribution to marketing of new products. Food security also involves population growth. Raising food output is essential but so is the slowing of population growth and maintenance of the ecological balance.

This would mean that the major challenge to produce additional food, fibre and fuel must be accompanied by conservation of the depleting natural resources. The attempts by the oil palm industry to actualize the 3Fs objective by using the same oil palm land for the production of protein and carbohydrate through LCI should be supported as food security initiatives so as to strengthen the focus on a diversified food basket, and not just that of oils and fats. Food security must not be based on market demand alone, but rather on self-reliance and sufficiency, and efforts by the oil palm industry as a whole.

Ensure Appropriate Application of Research, Science and Technology

The impact of R&D on the 3Fs objective is decisive in that there should be monitoring, evaluation and improvement of field and mill operations when actualizing the 3Fs objective. An area-specific database of the natural resources should be developed and made available for planning, implementation, research and extension. Existing data information should be assembled, verified and put into a useful and easily accessible form. Such well-designed information technology package once developed should help serve as market information network together with other weather, pest and disease monitoring systems that could also be used as a storehouse of current technologies and practices for realization of the 3Fs objective.

The farming system should be refined to achieve the 3Fs objective. It is best to harness the eco-technologies resulting from a blend of indigenous knowledge with frontier technologies. Such tools should include bio-technology, information and communication technology, GIS mapping, renewable energy technologies, management and marketing technologies. In the case of biotechnology, bio-safety and bio-surveillance are considered important factors. The 3Fs production should originate from

efficient and environmentally sound production technologies that conserve the natural resources.

Recognizing the Value of Biodiversity

The value of a plantation or planted trees in relation to agricultural biodiversity would depend on what was previously present on the site and also on the type of landscape in which it occurs. The reforestation of degraded logged-over land and abandoned land with a dense oil palm planting would produce the greatest benefit from such tree crop management. It is vital to recognize that the intrinsic value in agricultural biological diversity lies in its ecological, social, economic, scientific education, cultural and aesthetic importance. In the oil palm plantation, this agricultural biodiversity is being rediscovered to enhance actualization of the 3Fs objective.

The high priority given to safeguarding as much of the existing unique and valuable agricultural biodiversity (Chan, 2004), both in the *ex situ* collection of plant genetic resources such as the various oil palm germplasm collection, and through the *in situ* conservation in their oil palm habitat such as the various soil types and locality, has led oil palm plantations into using natural predators in integrated pest management. Cooperation with the national programmes and international institutions to sustain *in situ* and *ex situ* conservation efforts need to be strengthened further. Efforts to catalogue and classify the vast agricultural biodiversity within the oil palm system with special emphasis preserving species involved in IPM and other natural control is highly commendable.

Strengthen Extension and Capacity Building Mechanisms

Agricultural extension must focus on increasing production and productivity of the 3Fs in an economically and environmentally sustainable way. It must be done to strengthen the rural livelihood and rural communities. Extension services must result in positive changes in rural areas. This means helping the smallholders towards sustainability and higher productivity. It also demands measuring their success in terms of their contribution to the achievement of the 3Fs objective. The extension services should also support a system that meets the need of information, especially for educated women and youths, so that they are empowered with new skills and techniques from the new agro-businesses that foster sustainable agriculture

Promote Awareness and Education Activities

National policies and planning should recognize that public awareness also play an important role in establishing a firm basis for the 3Fs objective to be fulfill in a sustainable manner. Public awareness should be extended to all four levels of the local company, industry, nation and global arena. National strategies should strengthen the 3Fs objective for the target audiences, partners and tools for public outreach. Government and industry should encourage NGOs in raising public awareness with the 3Fs objective. It is important to organize public information programmes and public discussions to share the work to publicize the 3Fs objective.

Create Favourable Economic Climate

Agriculture has, over time, become a relatively unrewarding profession due mainly to the fluctuating produce prices, low value addition, abandoning of farming and increasing migration from the rural areas. With the 3Fs objective in place and the integration of livestock and crops, there will be corrective measures to stem the tide of rural-urban migration and rejuvenate the image for agriculture. There will be better opportunities with the agro-businesses started in the 3Fs objective. They will bring back the shine to agriculture. A favourable economic and supportive environment and management from the food, fibre and fuel agro-businesses will become the key pillars for promotion of sustainable agriculture and food security.

With increasing income and companies, own investment in the production of 3Fs products, there are new avenues with which to combat the current uneven playing field faced by palm oil in combating the heavily subsidized production of oilseed crops in the developed countries. The 3Fs will open external and internal market reforms, backed by the government domestic market structure for the 3Fs products. This will create a favourable economic environment for agriculture so that the rural populace involved in the 3Fs objective can better withstand the impacts of globalization and trade liberalization. The flexibility in determining domestic agricultural policies and pricing arising from the 3Fs products will improve the productivity and enhance income by ensuring stable prices. All these efforts are made to create a level playing field in the global marketplace

In the context of globalization of the food market, growers can

improve their own market with downstream value-added products arising from the 3Fs objective where the agriculture sector can address its own production, pricing, distribution and access. With the agricultural food processing agro-businesses in place and with international health standards being promoted locally, this will facilitate international agreements for our food products that should allow the large agricultural dependent sector to venture overseas.

Likewise, the biomass-based entrepreneurship and fuel sector agro-business should be promoted to generate wealth in the rural sector. In fact, all the players in the whole value chain should be evaluated to monitor their performance as food, fibre and fuel processors, retailers service providers and distributors all the way to the end-users.

DISCUSSION

In the effort to adopt sustainable development, the oil palm industry has moved the whole concept of sustainability forward by paying special attention to the development of the 3Fs objective based on better LULUCF activities. The replanting cycle of oil palm fields up to 25 years offers biological mitigation of GHG through LULUCF and they are tackled by three strategies. They are, firstly, conservation of the existing carbon pools, *i.e. a*void deforestation in the production of palm oil due to its higher yield over the annual oilseed crops; secondly, sequestration by increasing the size of the carbon pools, *e.g.,* through afforestation and reforestation where the land is under semi-permanent tree cover as offered by oil palm plantations; and, thirdly, due to its fibre and fuel production they can produce renewable fuel such as biomass.

This approach is now taken seriously at all four levels of (local company, industry, national and global) where the agricultural policy is being reviewed to protect the emerging agricultural food, fibre, and fuel industries to ensure high quality food, fibre, and fuel products are available at modest prices.

During the past decade, we have made inroads in agriculture. We brought on the fusion of space age technologies with other scientific facts and skillfully managed crop production systems. Yields have started to be improved again and environmental protection enhanced. Most activities have benefited suppliers, producers and consumers along the value supply chain. The contributions of the leaders and the followers are gratifying. The testimony will encourage the followers to step up the challenge of bringing agriculture to even greater height. This is to be spearheaded by R&D along the following broad areas:

- higher crop yield. We need to evaluate for the next decade how the 3Fs objective is to be fulfilled. Areas like biotechnology, site-specific precision agriculture, nutrient management planning and influence of management would receive higher priority. They all lead to improved crop yields. We believe that this single overarching objective is critical to reducing unit costs for growers, meet the global food needs and enhance the environmental quality.
- crop quality and specific end-uses such as nutraceutical and functional foods to be incorporated into food use. How, through the biodiesel fuel production pathway, these phyto-nutrients are efficiently extracted.
- use of the Internet for effective dissemination of information more rapidly and in a more site-specific fashion so as to optimize efficient use of the depleting natural resources.
- improve crop yield by narrowing the gap between attainable and realized yield and what key practices such as nutrient management planning to apply to narrow the gap.
- employ sound science to deal with the issues on soil, water, air and environment.

Can the oil palm provide sufficient food, fibre and fuel for the world's growing population with the shrinking per capita land base? The answer is *yes.* The oil palm industry can do it, provided new technologies are develop that allow us to grow more per unit land area and we remain committed to stewardship of the 3Fs.

Taken together, the 3Fs objective provides the working perspective for us to contribute to the improvement of agricultural productivity, the economics and environmental protection. Among the 3Fs, once the first *F* food security is provided, people and their societies will develop in significant and meaningful ways to go beyond science, research, education to use the second and third *F*s of fibre and fuel to boost the real income of the society.

Finally, we ask ourselves the question, "Am I making a difference?" How well do we do in bettering the lives of people, then we can start to address the issue of the 3Fs. We have good and dedicated researchers in oil palm. We have to replace the outdated policies and convince those people who are against change. Luckily, there are enough positive people to

harness so that the positive individual contributions combined have resulted in an industry positive action. We need to replicate these positive people to reach out to others in science and education in industry, in policy making and in the plantations that together we will make the difference.

CONCLUSION

Commitment to excellence characterizes the planting community. They all deserve a tip of the hat for their contributions to the industry, local community and the global economy. Agronomists and soil scientists are literally people with their feet on the ground and their hands on the soil. What they do bring progress to society. We must not be slowed by the limitation of minds. Together, we can challenge this limitation of minds. Let us bring together teams of skilled, committed and experienced people from different disciplines and diverse backgrounds and, as a team, move agriculture forward to have sufficient food produced for nations and provide environmental security for our global village. What is critical to us is to challenge, to actualize and fulfill the 3Fs objective by optimally exploiting the oil palm land.

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