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THE NEED TO REDUCE NATIONAL GREENHOUSE GASES EMISSIONS: OIL PALM INDUSTRY'S ROLE

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ABSTRACT

Malaysia ratified the United Nations Framework Convention on Climate Change (UNFCCC) in 1994 and the Initial National Communication (INC) submission based on 1994 inventory of emissions and removals was submitted in 2000. Now with the coming in force of the Kyoto Protocol on 16 February 2005, the preparation of the Second National Communication (NC2) would be a continual step towards Malaysia's commitment on the national implementation of UNFCCC. The approach and process consisted of a self-assessment of the national greenhouse gases (GHG) inventories that would include measures undertaken to adapt and to mitigate climate change. The objective would be to improve NC2 submission in 2006 by addressing the gaps identified during the preparation of INC. The NC2 would cover all sectors that would be vulnerable to climate change. For each of the sector identified, an inventory of possible sources of GHG emissions/removals was listed. Under INC only five broad sectors of energy, industrial process, agriculture, land-use and land-use change and forestry, and waste, had their emissions and removals through sequestration identified and quantified.

In updating the GHG inventory for the base year 2000, the 1996 IPCC revised guidelines were used, and the 1994 inventory was also recalculated using the 1996 guidelines. The vulnerability and adaptation of the oil palm plantations activities were assessed for all seven sectors of agriculture, forestry, biodiversity, water and coastal resources, public health and energy. As for the mitigation of climate change, however, the oil palm industry activities for five sectors of energy, agriculture, waste, land-use and land-use change and forestry, including the use of clean development mechanism (CDM) was reviewed. The details of adaptation and mitigation measures undertaken by the oil palm industry activities were prioritized in the NC2. From the prioritization, improvement in GHG inventory, adaptation measures and mitigation options were used to compute as accurately as possible the total GHG emissions to determine whether the industry is a net emitter or sequester of GHG emissions. The positive contribution by the oil palm industry in reduction of GHG emissions would be used to assist in the computation of the net national GHG emissions when the other industries' sectors net emissions would be totalled up. The role and contribution of the oil palm industry in enhancing reduction of national GHG emissions would be highlighted. The paper provided firm recommendations to improve the computation of GHG emissions by focusing on capacity building process, coordination, sustainable development and integration of climate change programmes in the medium- to long-term planning of the palm oil industry.

Keywords: oil palm, eddy correlation, canopy photosynthesis, evapotranspiration, drought.

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INTRODUCTION

As Malaysia marches on to become a developed nation by 2020, the rapid economic changes in the urban and rural areas of the country will pose many environmental challenges. One of them is the need to have energy for development. Sustainable development means doing those things that nurture mankind's aspirations by providing society's needs while ensuring a safe and viable environment for the resources we live on…. and in…. (Stauffer, 1999). Since the 1970s, several principles of sustainable development have been integrated into the national development whereby a balance between environmental and developmental demands is met. The environmental requirements are to ensure sustainable economic growth with effective protection of environment and natural resources. The *National Millennium Development Goals (MDGs) 2015 Report* prepared by the Economic Planning Unit (EPU) was launched by Datuk Mustapa Mohammed, Minister in the Prime Minister's Department in January 2005 to provide the thrust to achieve such a balance between environment and development.

MPOB had earlier highlighted some future scenarios where between 2020 and 2050 there would be a need for Malaysia to account for its GHG emissions as a developed country (Yusof and Chan, 2004). Arising from this there would be a need to prepare a national carbon balance sheet and the oil palm industry (Chan *et al*., 2003) would be included where the emissions and the removals by sequestration by the oil palm would be balanced in relation to total production. The proposed carbon balance paper, presented initially at PIPOC 2003, had identified several weaknesses in the computation of the GHG inventory. There was too much reliance on the use of the Intergovernmental Panel on Climate Change (IPCC) default values for estimation of GHG emissions and for removals.

The need to develop the local emission factors was highlighted. They had to be established so as to improve the accuracy of the precise extent of GHG emissions and the removals. Over the past two years, local capacity had also started to be built up and current efforts in developing local emissions factors would result in more accurate estimates than those used previously in the Initial National Communication in 1994.

MALAYSIA'S SUBMISSION OF INITIAL NATIONAL COMMUNICATION

In July 1994, Malaysia having ratified the United Nations Framework Convention on Climate Change (UNFCCC) demonstrated a commitment by submitting its Initial National Communication (INC) based on 1994 figures to UNFCCC in 2000. The INC was an ample proof of the importance the country had given to the fulfillment of the commitment made by the country under the UNFCCC. In the process, the country had the opportunities to enhance institutional capacity in computing GHG emissions baselines among the various industries. At the same time, there was an increased awareness of the responsibilities of both public and institutions concerning the GHG emissions and their removals on global warming and the country took a stand to responsibly contribute to the efforts for enhancing climate change abatement.

By 2006, the country would be expected to submit its Second National Communication (NC2) based on the 2000 baseline of GHG figures. The main priority would be an upgrading of the computation of the GHG inventory within NC2 by ascertaining the results of the estimated INC GHG emissions. By reducing the number of uncertainties, greater emphasis on verification and interpretation of collected data for the country would enable a more user-friendly database system to be developed. This would also improve the capability for future updating of the GHG inventory.

The GHG inventory used for reporting NC2 based on year 2000, would be in accordance to the decision taken at Conference of Parties (COP 8) under the UNFCCC held at New Delhi, India in 2002 as outlined in Decision 17/CP8.

OBJECTIVE OF PAPER

The objective of the paper is to show how the palm oil industry can support the Government of Malaysia's commitment to the UNFCCC project by commencing from January 2005 onwards to prepare the NC2 at the national level and culminating in its submission to UNFCCC by the end of 2006. The objective of this paper is three-pronged:

- firstly, to reflect on the seriousness of the oil palm industry in helping the Government of Malaysia in honouring the country's commitment to the UNFCCC. A carbon balance over the whole industry would need to be constructed;
- secondly, by presenting this important paper at PIPOC 2005, the oil palm industry would be seen moving ahead in its stocktaking of the GHG emissions and removals; and reflecting on its efforts in achieving sustainable development by demonstrating whether it can contribute to the reduction of national GHG

emissions thereby reducing global warming; and

- thirdly, to allow the oil palm industry locally, nationally and also internationally to prioritize resources to adapt to climate change and to mitigate any adverse impacts on oil palm yields, socioeconomic conditions, biodiversity, coastal management, energy, public health and water issues.

Hence, in creating awareness on the climate change-related advances in science for the reduction of GHG emissions and removals through carbon sequestration by oil palm, it would be possible to determine whether its role would be positive or not. The effort made here would represent an attempt to improve and sustain the philosophical, technical and institutional capacity of the industry in meeting the obligations under the UNFCCC and in planning and implementing climate change integrated sectoral and national development objectives. It is to improve the industry and ultimately the country capability to undertake adaptation and mitigation measures to minimize climate change.

UNDERSTANDING THE COMPLEXITY OF GLOBAL WARMING ISSUES ARISING FROM INC

The Malaysian palm oil industry must understand the complexity of global warming and there are two major considerations.

The Sheer Size of the Industry from the National Perspective

Despite the scientific complexity of global warming related issues, the efforts made during the INC submission in 2000 based on 1994 baseline assessment showed that:

- firstly, oil palm with areas at 2.412 million hectares in 1994 would be good to find out the role whether there was an overall GHG emissions reduction through its sequestration by sinks. In scanning an overview of the national circumstances and complexities of the country in terms of geographical dimensions, distribution and as well as development priorities at that time, oil palm should feature prominently;
- secondly, when consolidating data of the Malaysian GHG inventory during the assessment year 1994, the amount of GHG removals by sinks, estimated in INC to be nearly half of GHG emissions, would certainly require separate computation of the contribution to the removal of GHG emissions by sinks of forests and other major tree crops including oil palm; and
- thirdly, in comparing the other various industries with the oil palm industry, the main weakness highlighted in the INC would be the need to report all direct or indirect GHG emissions. It is in the interest of a more transparent, complete, reliable and consistent accounting that as accurate as possible of the overall national net GHG figure should be assessed.

A summary of the reported national GHG emissions computations in INC under the six sectors had indicated that a low net emissions figure of 28.6 million tonnes of CO_2 in 1994 is recorded as shown in *Table 1*.

TABLE 1. SUMMARY OF NATIONAL GREENHOUSE GAS EMISSIONS AND REMOVALS IN 1994

Categories	CO_2 (Gg)	CH_4 (Gg)	N_2O (Gg)
Energy	84 415	635.13	0.35
Industrial process	4 973	-	-
Agriculture	-	329.3	0.054
Waste	318	1 266.5	-
Land-use change and forestry (emissions)	7 636	0.13	0.001
Total emissions	97 342	2 231	0.405
Land-use change and forestry (sinks/ removals)	(68 717)	-	-
Net total emissions (less sinks/removals)	28 628	-	-

Sources: After Chan *et al.* (2003); Adapted from MOSTE 2000; 1 Gg= 10^9 g or 10^6 kg or 10^3 t.

On a national scale, the country's GHG emissions figure in 1994 (computed based on IPCC 1995 guidelines and methodologies) was 97.3 million tonnes of CO_2. The amount removed by sequestration in the sinks was 68.7 million tonnes thereby leaving a residual amount of emissions of 28.6 million tonnes or Gg of CO_2. On per capita basis, the net emissions amounted to 3.7 t CO_2.

In terms of GHGs, CO_2 accounted for 67.5%, methane (CH_4) 32.4% and nitrous oxide (N_2O) 0.1% of the total CO_2 equivalent emissions.

Among the six sectors, energy with its fuel combustion accounted for 86.7% of the total CO_2 emissions. As for CH_4, land fills under waste accounted for 46.8% while fugitive emissions from oil and gas under energy accounted for 26.6% both adding to 73.4% of the total CH_4 emissions. For N_2O, the traditional biomass fuels under energy accounted for 86.4% while fertilizers under agriculture added another 13.3% giving a total of nearly 99.7% of the N_2O emissions.

Problems Identified, Lessons Learned and the Way Forward from the INC Submission

Gaining from the experience in doing the INC, the main problems identified, lessons learned and the way forward where the palm oil industry can lend its support are:

a) The problems identified were:

- gaps and uncertainties of some data;
- non-availability of related local emissions factors;
- need to establish localized emissions factors; and
- need to strengthen institutional capacity to collect and collate data.

b) The lessons learned:

- the IPCC guidelines 1995 used for computing the inventory for the base year 1994 during the self-assessment of the INC would have to be revised by using the IPCC 1996 guidelines;
- the priorities are for a more accurate reporting of CO_2, CH_4 and N_2O in all the five sectors of energy, industrial process, agriculture, land-use change and forestry, and waste; and
- Malaysia, as a developing country, though has more pressing needs to eradicate poverty, improve health conditions, fight malnutrition and ensure upgrading of living conditions, yet the nation chooses to tackle the GHG emissions reduction pathway in addition to achieving the sustainable development. This is because, as the country feels that in moving towards attaining a developed country status by 2020, the Malaysian Government is conscious of the concerns for mankind when it ratified the UNFCCC in July 1994.

c) The Way Forward for NC2:

The way forward from INC when computing NC2 would be:

- to involve more businesses and industries and their respective government ministries in requiring them to send their experts to join in the discussions of the problems identified and the lessons learned;
- to reduce uncertainties;
- to verify and interpret the collected data; and
- to develop user-friendly methodologies and database for quicker updating of submissions of national communication in future.

MALAYSIA'S PREPARATION TO SUBMIT THE NC2

There are six areas to be considered when preparing for the submission of NC2 and again the palm oil industry should lend its support. They are:

Malaysia's Commitment

In the preparation of the NC2, Malaysia as a developing country could take the easy way out by following the UNFCCC negotiated stand that allowed developing countries to stick to sustainable development and by not to have to meet any commitments to reduce or limit anthropogenic GHG emissions targets as required for the developed countries as confirmed by the Kyoto Protocol. With only sustainable development to achieve, the country could well focus solely on improving the more pressing social and economic needs such as poverty eradication, improving educational and health conditions, and fighting hunger.

However, Malaysia feels that achieving a sound environment through reduction of GHG emissions, at all three local, national and global levels, could well be decisive for the survival of the human race in the long run. Thus, the country, in choosing to play a more honourable role by significantly contributing and working towards GHG emissions reduction in the international negotiations on climate change, has been present for negotiations in all the COP meetings of the UNFCCC ever since 1992.

In fact, on the ISO front, Malaysia has also been chairing a working committee to develop a GHG standard ISO 14064 for the qualification and reporting of GHG emissions and removals at the organization and project levels and for the validation and verification of the GHG assertions (Chan, 2005).

Since the country has opted to work towards reducing the GHG emissions even though no targets have been set for us as a developing country and to achieve sustainable development at the same time, the palm oil industry remains committed to support the nation's effort to achieve both.

Meeting the New Requirements when Submitting NC2

For NC2 preparation, the country is aware that baseline year is set at 2000 and would require the use of the following:

- the revised or updated 1996 IPCC guidelines adopted by COP of the UNFCCC for Non-Annex I Parties;
- the 2000 IPCC Good Practice Guidance and Uncertainty Management for National GHG Inventories; and
- the 2003 IPCC Good Practice Guidance for Land-Use and Land-Use Change and Forestry (LULUCF).

The NC2 would require improvement in the computation work done. Attention would be placed in addressing the gaps identified during the INC compilation based on the national GHG inventory of the emissions/removals done in 1994. The three areas given focus in NC2 are as follows:

- national GHG inventory to be updated with the baseline year of 2000;
- development of adaptation programmes to climate change; and
- measures to mitigate climate change.

The above three areas would be examined by all industries/government ministries across all sectors and the palm oil sector is not to be exempted. They have to:

- establish linkages between industries;
- strengthen dialogue among ministries;
- exchange information between industries/ministries; and
- seek cooperation and collaboration among all stakeholders including government, non-government, academic and private entities.

The joint work to be undertaken collaboratively by the various industries and government ministries would represent a small step towards improvement but a big step towards better understanding of how the different GHG reduction across sectors could contribute to the lower net overall emissions/removals by computing all their respective anthropogenic activities in the country.

Sources of GHG Emissions

In the INC inventory prepared according to the 1995 IPCC guidance for the base year 1994, only three GHGs viz., CO_2, CH_4 and N_2O were reported. For the preparation of the NC2, the oil palm industry under the Ministry of Plantation Industries and Commodities, Malaysia, like other industries, is ready to examine the economic, environmental and social aspects of sustainable development for the emissions of all the six GHGs coming from the various sources under the Kyoto Protocol as shown in *Table 2*.

TABLE 2. ANTHROPOGENIC GHGs AND SOURCES

GHGs	Sources
CO_2: carbon dioxide	Fossil fuel combustion, deforestation, agriculture, plantations.
CH_4: methane	Agriculture, plantations, land-use change, biomass burning, landfills.
N_2O: nitrous oxide	Fossil fuel combustion, industrial, agriculture, plantations.
HFCs: hydrofluorocarbons	Industrial, manufacturing.
PFCs: perfluorocarbons	Industrial, manufacturing.
SF_6: sulphur hexafluoride	Electricity transmission, manufacturing.

Sources: Kyoto Protocol, Annex A; IPCC (2001).

Luckily for the palm oil industry, the main GHGs remain as CO_2, CH_4 and N_2O.

Clean Development Mechanism to Reduce GHG Emissions

Further to the impacts of the six GHGs emissions on global warming and climate change, they potentially can affect the yield performance of the oil palm. The palm oil industry must learn to adapt to such climate change and at the same time should explore new opportunities for developing cleaner technologies to mitigate the reduction of GHG emissions using one of the three mechanisms developed by the Kyoto Protocol called Clean Development Mechanism (CDM). The other two mechanisms are joint investigation (JI) between Annex 1 Countries, and International Emissions Trading (IET). The CDM in fostering the science for reducing GHG emissions and the removals would also be enhancing the palm oil industry to improve the transfer of new technologies from developed countries to them to mitigate the risk of climate change. The eligible sectors where the sources of GHG emissions reduction and the GHG removals could be selected for qualifying for CDM credits are shown in *Table 3*.

TABLE 3. ELIGIBLE SECTORS AND SOURCES THAT CAN QUALIFY FOR CDM CREDITS

Sector	Source categories
Energy	Fuel combustion, energy industries, manufacturing industries, construction, transport, fugitive emissions from fuels, solid fuels, oil and natural gas.
Industrial process	Mineral products, chemical industry, metal production, production and consumption of halocarbon and sulphur hexafluoride.
Solvent and other products use	Agriculture, enteric fermentation, manure management, rice cultivation, agricultural soils, prescribed burning of savannas, field burning of agricultural residues.
Waste	Solid waste disposal on land, wastewater handling, waste incineration.
Land-use, land-use change and forestry	Afforestation and reforestation, woodlots, plantations, agroforestry.

Source: Kyoto Protocol, Annex A.

From *Table 3*, the oil palm industry would be in a position to appreciate that within each sector there are many new opportunities for potential CDM projects to be developed and to earn carbon credits. They can come from:

- end-use energy efficiency (EE) improvement;
- supply-side EE improvement in boilers;
- renewable energy (RE) from biomass;
- fuel switching through biofuels;
- reduction of CO_2, CH_4 and N_2O emission in agriculture;
- industrial processes to reduce CO_2 from say biodiesel and biofuel projects; and
- sink projects from afforestation and reforestation.

Some potential CDM projects that await development in the oil palm industry are shown in *Table 4.*

It is good at this juncture to note that the palm oil industry must understand in the short- to medium-terms the companies may not face carbon constraint in energy use for its growth but in the longer-term companies should see climate change as a strategic issue. This means that emissions-intensive activities and emissions-intensive products will increasingly face regulation and market restrictions. The palm oil industry therefore needs to find ways in which productive activities like CDM projects and products themselves can be compatible with the long-term carbon constrained future.

Call for National Collaboration between Industries and their Government Ministries

In the overall national NC2 computation of the emissions and removals so as to derive the new emissions figure, there would be many activities consisting of painstaking stocktaking involving stakeholders' consultation to meet the country commitment under UNFCCC since the ultimate aim is to address sustainable development and climate change issues together. Led by the Ministry of Natural Resources and Environment (MNRE), the NC2 project would need the cooperation of a host of other industries and their government ministries and agencies as listed in *Table 5*. The palm oil industry under the Ministry of Plantation Industries and Commodities is definitely collaborating on this GHG computation nationally.

The reason to include in the list of government ministries here is to show that following the 2003 general elections there is a new government structure with many industries being realigned according to the new government ministries structure. Special attention would be paid to the various government ministries as there would be new information and data related to the various sectors that would either be vulnerable to climate change such as agriculture, biodiversity, coastal management, public health and water resources or would have GHG emissions or removals as sinks to account for as in energy, industrial processes, agriculture land-use and land-use change, forestry and waste sectors. The updated information would facilitate even better planning of adaptation and mitigation measures.

TABLE 4. POTENTIAL CDM PROJECTS IN THE SEVEN SECTORS

Sector	Project examples
Energy	
Power generation	Combined-cycle turbines, distributive network
Fuel switching	Natural gas, methane, biomass and biogas
Cogeneration	Biomass, chemical co-products
Renewables	Biomass, biofuels, biogas
Efficiency	More efficient equipment, processes and designs
Industrial process	
Efficiency	Boilers, motors, replacements, lighting
Cogeneration	Chemical, papers, oil refining
Retrofits	New machineries, steel
Production process	Efficiency improvement in design and production
Agriculture	
Agriculture	Manure management for biogas and fertilizer efficiency
Zero burn	Mulching with organic debris from palm oil production
Waste	
Recovery	Value-added products
Land application	Fertilizer substitute, enrich soil fertility
Land-use, land-use change and forestry	
Afforestation and reforestation	In open areas and reforest ex-grassland with oil palm, agroforestry, woodlots
Transportation	
Fleet vehicles	Alternative fuel vehicles
Mass transit	Expand present form, light rail
Housing	
Conservation	Education and outreach
Appliances	Solar water heaters, biomass and biogas cooking stoves
Lighting	Fluorescent light bulbs, improved interior design

TABLE 5. MINISTRIES, RELATED AGENCIES, NGOs AND UNITED NATIONS BODIES INVOLVED IN NC2 PREPARATION

No.	Ministries, Agencies, NGOs and UN Bodies
1	Ministry of Natural Resources and Environment (chair and secretariat)
2	Ministry of Agriculture and Agro-Based Industries
3	Ministry of Energy, Water and Communication
4	Ministry of Finance
5	Ministry of Health
6	Ministry of Housing and Local Government
7	Ministry of Plantation Industries and Commodities
8	Ministry of Science, Technology and Innovation
9	Ministry of Transport
10	Economic Planning Unit (EPU) Prime Minister's Department
11	Malaysian Meteorological Services Department
12	Representatives from Sabah and Sarawak
13	NGO representative
14	United Nations Development Programme (UNDP) Representative

The duties of the NC2 multi ministries committee are to:

- provide strong management support and overall policy advice, and assist in mobilizing available data and expertise of the various businesses and industries under their respective ministries;
- endorse work plan and reports;
- monitor and review project progress; and
- ultimately propose the final NC2 report for adoption by the government for its submission to UNFCCC.

The committee would meet once every six months and the aim would be to ensure that all project activities are integrated into existing institutional government structure on climate change. As the oil palm industry comes under the Ministry of Plantation Industries and Commodities, it would have to play its role.

ROLE OF THE OIL PALM INDUSTRY

The role of the palm oil industry is to coordinate and oversee preparation of the inputs from the various companies, stakeholders and players within and around the palm oil industry under the Ministry of Plantation Industries and Commodities by computing the industry's contributions towards the country's final output of NC2. There must be sufficient communication and adequate information flow among all concerned to ensure all sources of GHG emissions/removals from the three agreed aspects: (1) GHG inventory (2) adaptation improvement and (3) mitigation measures.

Details obtained from these three aspects would go to show the overall improvement of the national communication of NC2 over that of INC for submission to UNFCCC by end of 2006.

Technical Components of the Three Aspects of GHG Emissions and Removals

GHG inventory

There are two important considerations.

a) Involvement of the Oil Palm Industry and Ministry of Plantation Industries and Commodities for Completeness, Consistency, Transparency and Reliability in Data Collection when Compared with Other Industries

Firstly, when the country submitted the INC in 2000, the pioneering effort on reporting was made based on the 1995 IPCC guidelines for assessment of the baseline year 1994. The scientific complexity of global warming and the resulting difficulties in understanding holistically the climate change then was accompanied by the lack of human and financial resources to develop a more comprehensive climate change modelling study. This included the study of the effect of climate change on yield performance in the oil palm industry (Chong and Matthews 2000; Chan *et al*., 2003). Despite the shortcoming, this had made the INC submission even more than noble in that it had benefited the various institutions which were involved then in the process of developing the INC submission document.

Secondly, this time round in the preparation of NC2, the institutional framework under MNRE has been set-up and there is strong involvement of other ministries and agencies. The oil palm industry is now more prepared. The wide-ranging detailed nature of the data collection for the GHG inventory would involve attempts, for completeness, to capture the diverse information available in the other numerous industries and government ministries. The producing industries including the palm oil industry and their sectors with their experts, with the experience gained from computation from INC, would be in better position in adapting the 1996 IPCC methodology (where developing countries counterparts had little role in developing) to make a more accurate and reliable NC2. Despite the difficulty, the palm oil industry with its current stage of scientific knowledge and availability of human and financial resources would be able to minimize the uncertainties when appraising the GHG emissions, and removals by sequestration.

Thirdly, as NC2 computation requires the development of detailed national data for the GHG inventory, the work would be resource-intensive. Fortunately, the palm oil industry under the Ministry of Plantation Industries and Commodities has relatively much more scientific information available to derive the consistent and reliable data. However, for certain other industries, there is little information in the various sectors. Further, in some other industries, there is no specific information available at all for such sectors. Under such circumstances, the information from a range of non-related work reported elsewhere done previously by other national institutions would have to be used to complement the default emissions figures provided by IPCC 1996 guidelines.

Fourthly, as determined by the UNFCCC, the 1996 revised IPCC inventory guidance require as complete as possible the sources and sinks of the GHG emissions and removals that would result from all human anthropogenic activities. For completeness, the national inventory would have consider the emissions of CO_2, CH_4, N_2O, hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulphur hexafluoride (SF_6) as listed in *Table 2* earlier.

Finally, for the oil palm industry, the emissions though confined mainly to the first three direct GHGs consisting of CO_2, CH_4 and N_2O in the INC would now include where possible, other emissions from indirect GHGs such as nitric oxides (NO_X), carbon monoxide (CO), sulphur dioxide (SO_2) and other non-methane volatile organic compounds (NMVOCs). Both the quantities of the direct and indirect emissions would be estimated under the sectors *viz*., energy, industrial processes, solvent and other product use, agriculture, land-use and land-use change, and forestry and waste as listed in *Table 3*.

b) Need for Clarity and Accuracy

In computing the emissions and removals, there is a need for clarity and accuracy where the methodologies used indeed must be clearly spelt out. This is to meet the requirements of global stakeholders who come from different cultures and languages. Traditionally, the oil palm industry would cover the production of palm oil as food, and this would therefore involve mainly the agriculture sector. However, as the same land under the agroforestry concept is now used to produce carbohydrate and protein food sources through intercropping and livestock integration, there would be emissions from enteric fermentation in domestic livestock and the manure management to be considered and to quantify the GHGs emissions there from. The aim is to be as clear and as accurate as possible when collecting the data and interpreting the information.

Characterization of the size of the Malaysian palm oil industry

In compliance with the requirements of INC and NC2, the oil palm areas in 1990, 1994, 2000 and 2004 were listed as shown in *Table 6*. The four benchmark years were chosen to show i) 1990 as the starting base year of comparison, ii) 1994 being the baseline year selected for INC, iii) 2000 being the baseline year for NC2 and iv) 2004 just to give the readers the latest situation. It can be seen from *Table 6* that there is a steady increase in area under oil palm from 1990 onwards. As of 2004, oil palm at 3.875 million hectares occupied about 64% of the land allocated to agriculture. The founding fathers in their early projection had allocated 6.2 million hectares to agriculture (Third Agricultural Plan, 1998-2010).

The vast agriculture land potential together with the country's practice of free enterprise, the oil palm industry grew steadily within the 6.2 million hectares of agricultural land area allocated. However, this means that the expansion was done at the expense of much of the rubber, coconut, cocoa and other fruit crops.

Firstly, in 1994 the increase of oil palm from 1990 was 0.383 million hectares and this was brought about by 0.099, 0.122, 0.023 million hectares of rubber, cocoa, and coconut respectively giving a total of 0.244 million hectares being planted to oil palm. No attempt was made here to show the changes in the oil palm areas that were taken out of cultivation as there were some that were cleared for uses such as roads, industrial and housing development. Only the net increase is reported. As the rest of the areas of

TABLE 6. TOTAL AREA (10^6 ha) UNDER SELECTED CROPS

Crops	1990	1994 (baseline year INC)	2000 (baseline year NC2)	2004
Oil palm	2.029	2.412	3.377	3.875
Rubber	1.837	1.738	1.431	1.282
Cocoa	0.393	0.271	0.076	0.045
Coconut	0.314	0.291	0.159	0.146
Pepper	0.012	0.011	0.013	0.014
Pineapple	0.009	0.008	0.007	0.006
Tobacco	0.010	0.010	0.016	0.012
Paddy	0.681	0.699	0.699	0.675
Coffee	0.018	0.017	0.012	0.012
Tea	0.003	0.003	0.003	0.003
Total	5.306	5.460	5.793	6.079

Sources: Statistics on Commodities 2004 compiled from Department of Statistics, Malaysian Rubber Board and Malaysian Palm Oil Board.

crops, consisting of pepper, pineapple, tobacco, coffee and tea including paddy, were maintained they were therefore not brought into the *change in area* equation. The balance of 0.139 million hectares over five years or annually 0.028 million hectares is assumed to have come from logged-over forests or deforested land and perhaps some deforested peat land estimated to be at 25% of logged over forests.

Secondly, in the NC2 preparation, the baseline year is 2000 and the increase in oil palm area over 1994 was 0.965 million hectares. Of this, 0.307, 0.195, 0.132 million hectares are assumed to come from rubber, cocoa, coconut respectively giving a total of 0.634 million hectares converted to oil palm. Again the balance of 0.331 million hectares over six years or annually 0.055 million hectares assumed to come from logged-over secondary forest or deforested land and perhaps some cleared peat land also estimated at 25% of logged-over forests.

Thirdly, in 2004, the increase in oil palm area over 2000 came to about 0.497 million hectares where 0.149, 0.031, 0.013 million hectares giving a total of 0.193 million hectares respectively came from rubber, cocoa and coconut. The remainder of 0.304 million hectares over the last four years or annually 0.076 million hectares of logged-over forests or deforested land or deforested peat forest land were converted to oil palm. In all three situations, the overall agricultural land bank of 6.2 million hectares, designated for agriculture, had been maintained. This implies good enforcement of land laws in the country.

The GHG emissions and removals

The GHG emissions and removals through sequestration are shown in the five sectors as follows:

Energy. Different activities when powered by fossil fuels produce different anthropogenic GHG emissions. The emissions include those from combustion and fugitive GHGs.

(a) Emissions from combustion of fossil fuels

This consists of firstly, of combustion of non-renewable fossil fuels. Indirect emissions from the plantation inputs like fertilizers, pesticides and herbicides requiring the use of fossil fuels for their manufacture would also have to be accounted as seen in *Table 7*.

The use of biocontrol measures for example through integrated pest control (IPM) would reduce use of pesticides and therefore reduce indirect emissions emitted by use of fossil fuels to manufacture pesticides. The emissions of GHGs include CH_4, N_2O, CO, NO_x and NMVOC that can come from fossil fuels used directly to power transport and machinery in the plantation and to convey materials to and fro to the mills. It must be noted that in computing the carbon balance, the energy for mill processing of 0.799 million tonnes per year can be reduced as there is excess of such biomass for energy production. Usually 90% of the empty fruit bunches are recycled as mulch. Likewise the energy for fertilizer could be reduced as empty fruit bunches at a rate of 4 ha to mulch back 1 ha and palm oil mill effluent from 10 ha can be recycled to 1 ha in terms of nutrient needs. Usually 70% of POME is recycled. Also with the use of IPM, there will be reduction in energy used for herbicide.

(b) Reduction in emissions from fossil with energy replacement from combustion of renewable fuels

As renewable energy sources, fibre, shell and empty fruit bunches, are combusted in the 380 mills in 2004 to supply energy to mills, refineries and also manufacturing especially if the mill processing,

TABLE 7. ENERGY USE, THEIR CARBON EQUIVALENT AND TOTAL GHG EMISSIONS (million t ha^{-1} yr^{-1}) DERIVED FROM DIRECT AND INDIRECT FOSSIL FUEL USE BASED ON TOTAL PLANTED AREAS OF OIL PALM IN THE FOUR BENCHMARKED YEARS OF 1990, 1994, 2000 AND 2004

Sources	Energy (GJ ha^{-1} yr^{-1})	Carbon equivalent (kg ha^{-1} yr^{-1})	1990 10^6 t yr^{-1}	1994 (INC) 10^6 t yr^{-1}	2000 (NC2) 10^6 t yr^{-1}	2004 10^6 t yr^{-1}
Direct vehicle & machinery fuel	4.70	83.30	0.169	0.201	0.281	0.322
Mill processing energy	22.20	393.80	0.799	0.950	1.330	1.526
Fertilizers	10.25	181.90	0.369	0.439	0.614	0.704
Herbicides	1.86	33.10	0.067	0.080	0.112	0.128
Insecticides	0.01	0.23	0.0005	0.0006	0.0008	0.0009
Rodenticides	0.18	3.24	0.007	0.008	0.011	0.013
Workers	0.61	10.86	0.022	0.026	0.037	0.042
Total	39.81	706.43	1.434	1.705	2.386	2.736

Sources: Adapted from Wood and Corley (1993); Henson (2004).

refining and manufacturing become fully integrated. The CO_2 emissions from combustion of biomass fuels are considered as CO_2 neutral unlike emissions associated with the combustion of non-renewable fossil fuels like diesel. By using the energy generated from these renewable sources, they help to reduce emissions as carbon offsets against use of fossil fuel as shown in *Table 8.*

iii) Biogas from POME. In the palm oil mill for every tonne of FFB processed, about 0.7 t of POME is generated. The effluent is digested in anaerobic ponds. For every tonne of POME digested about 28.8 m^3 of biogas can be generated but this is not a common practice at the moment. The biogas, comprising of 65% methane (CH_4) and 35% CO_2, is a good source of energy with a heat value of 4740 kcal m^3. It is reported that for each m^3 of biogas being burned, 1.8 kWhr of electricity is generated. Thus, for the four benchmarked years, the biogas produced could have generated enough of electricity that will save diesel, and therefore applying 0.47 kg of CO_2 reduced for every kWhr of electricity generated, the quantities of CO_2 equivalent per year offset ranged from 0.122 to 0.280 million tonnes per year or 0.033 to 0.076 million tonnes C over the four benchmarked years (see *Table 8* row 5).

TABLE 8. TOTAL POTENTIAL CARBON OFFSETS FROM CO-PRODUCTS OF MILLING TO REDUCE EMISSIONS

Products	1990	1994 (INC)	2000 (NC2)	2004
FFB processed (10^6 t yr^{-1})	30.475	36.105	54.210	69.890
Fibre and shell (10^6 t CO_2 e yr^{-1})	0.286 (0.078)	0.339 (0.092)	0.507 (0.138)	0.657 (0.179)
EFB (10^6 t CO_2 e yr^{-1})	0.520 (0.142)	0.616 (0.168)	0.925 (0.252)	1.192 (0.325)
POME biogas (10^6 t CO_2 e yr^{-1})	0.122 (0.033)	0.145 (0.040)	0.218 (0.059)	0.280 (0.076)
Total potential CO_2 e (10^6 t yr^{-1})	0.928	1.100	1.650	2.129
Total potential C (10^6 t yr^{-1})	(0.253)	(0.300)	(0.449)	(0.580)

Source: Adapted from Ma (2002), figures in bracket are 10^6 t C yr^{-1}.

It must be stated here that between 1990 and 2004, the bunches were used differently such as being incinerated for bunch ash production but for the future and purpose of this study, the current potential for energy production and for carbon offset against use of fossil fuels is proposed.

i) Fibre and shell. It is estimated that about 20 kWhr of electricity is required to process 1 t of FFB. For every 1 kWhr of electricity generated by the combustion of fibre and shell about 0.34 litre of diesel is saved of which there is a reduction of 0.47 kg of CO_2. Thus, for the various amounts of FFB processed per year at the four benchmarked years, the savings of 0.286 to 0.657 million tonnes of CO_2 equivalent or 0.078 to 0.179 million tonnes of C are achieved as indicated in *Table 8* (2nd row). It must be mentioned here that in all the palm oil mills, there is usually an excess of fibre and shell that can be used as fuel. If all the fibre and shell are used to generate electricity, more carbon credits can be realized.

ii) EFB. At 23% extraction of FFB, each tonne of EFB can generate 109.28 kWhr of electricity. As each kWhr of electricity generated can save about 0.34 litre of diesel, there will be a saving of 0.47 kg of CO_2. Thus, if EFB were used instead of diesel for power generation over the four benchmarked years, the savings of 0.520 to 1.192 million tonnes CO_2 equivalent per year (vide *Table 8*, 3rd row) can be obtained from the combustion of EFB derived from the processing of the FFB. In actual fact about 20% of the EFB produced is used to generate electricity while 80% is used for EFB mulching and as mineral fertilizer substitute (see under EFB mulching).

As both CH_4 and CO_2 are GHGs that contribute to global warming, especially CH_4 with global warming potential of 21 times of CO_2 efforts to capture CH_4 as biogas is currently actively been undertaken by R&D in MPOB. The potential use of biogas must be made into reality as soon as possible.

iv) POME as fertilizer substitute. Currently about 70% of the POME is returned to the field as a fertilizer substitute (see POME application). Trials with spent POME after the biogas had been exploited showed that the nutrients in POME could still be an effective fertilizer substitute.

c) Development of energy efficient boilers

In continuous development of more energy efficient boilers for the combustion of fibre and shell, say with another 5% improvement in EE, there will be more *excess energy* available to be fed into the national electricity grid (vide *Table 9*).

TABLE 9. ADDITIONAL CARBON OFFSETS FROM FIBRE AND SHELL THROUGH 5% ENERGY EFFICIENCY (EE) WITH RESULTING REDUCTION IN GHG EMISSIONS

Products	1990	1994 (INC)	2000 (NC2)	2004
Fibre and shell (10^6 t CO_2 e yr^{-1})	0.014	0.017	0.025	0.032
Saving of emissions (10^6 t C yr^{-1})	0.0038	0.0046	0.0068	0.0087

Industrial processes. By and large, unlike the vegetable oilseed extraction that would sometimes uses solvent, there is no solvent use in the oil palm industry. The industrial process would probably be confined to the biodiesel production when it comes on stream. Currently, the palm oil industry together with the government is finalizing the plan to go large scale into biodiesel production.

a) Methyl ester process in biodiesel production

Palm diesel consists of methyl esters of palm oil prepared from the industrial reaction with methanol using a suitable catalyst. The process of conversion of palm oil into biodiesel involves the pre-treatment stage (esterification) to handle free fatty acids and the second stage of transesterification of the neutral glycerides directly into methyl esters. The process is continuous and yields palm diesel that had been thoroughly evaluated as a diesel substitute thereby reducing the use of fossil fuels. The production of biodiesel from palm oil could help to reduce the use of fossil fuel and such biofuel being renewable could also be used to drive transportation of farm machineries and other transportation. The burning of biomass fuels would help to offset emissions from use of fossil fuels.

Efforts are directed to convert 500 000 t CPO to biodiesel. Choo *et al*. (2005) reported on studies of the use of biodiesel from soyabean that resulted in 78% less CO_2 emitted than fossil fuel diesel. Thus, litre against litre comparison, biodiesel has less CO_2 at 0.6898 kg $litre^{-1}$ against diesel at 3.266 CO_2 kg $litre^{-1}$. The savings from 500 000 t of biodiesel of 0.129 million tonnes per year is shown in *Table 10*.

TABLE 10. REDUCTION OF CO_2 EQUIVALENT/YEAR AND CARBON FROM 500 000 t BIODIESEL

Type of fuel	CO_2 (kg $litre^{-1}$)	10^6 t yr^{-1} from 500 000 t
Diesel	3.2660	1.633
Biodiesel	0.6898	0.345
Potential savings CO_2e	-	1.288
Potential savings C	-	0.351

Source: Adapted from Choo *et al.* (2005).

Besides reduction of CO_2 emissions of 1.288 million tonnes or 0.351 million tonnes C from the 500 000 t of biodiesel, there is avoidance of SO_2 generation from fossil fuels when biodiesel is used.

b) Fugitive emissions

Here the emissions include those from vaporization from storage of fossil fuels, *e.g.* diesel and also storage of biodiesel fuels if any and are usually not associated with losses through non-useful consumption of fuel. The usual fugitive GHG emission is CH_4. The quantity would have to be ascertained when the biodiesel storage comes on stream.

Agriculture. Agriculture is an economic activity of great importance in Malaysia particularly for the plantation industry.

a) Standing biomass of oil palm

Between 1990-2004, a total of 1.845 million hectares of other crops and logged-over forests were converted to oil palm. Of these, the total area converted from other crops to oil palm was greater at 1.071 million hectares than from the logged-over forest at 0.774 million hectares. Among the crops converted, rubber at 0.555, was followed by cocoa at 0.348 and then coconut at 0.168 million hectares. As for the logged-over forests of 0.774 million hectares, according to the papers reviewed (Ariffin *et al.*, 1998; Lim and Dawson, 2003; Henson, 2004) about 0.136 million hectares of peat up to 2003 had been converted to oil palm. Hence, the estimated distribution of the areas converted to oil palm is showed in *Table 11*.

As 1994 was the baseline year when the INC was submitted, the change observed at 2000 being the baseline year for NC2, showed that the area of logged-over forest converted to oil palm was only 0.331 million hectares over the six years period of 1994-2000. The annual figure converted from ex-logged-over forests is small, at 0.055 million hectares or less than 1.63% of the total area at 3.377 million hectares. Of the logged-over forests, Henson (per. comm. 2005) estimated that there were 0.0329 and 0.0429 million hectares of oil palm growing on peat in 1990 and 1994 respectively giving an area of 0.0100 million hectares being converted to oil palm. Again an estimate of 0.0758 and 0.1360 million hectares of oil palm in 1995 and 2000 respectively were established on peat giving an area of 0.0622 million hectares being converted to oil palm.

b) Zero burn

The oil palm industry, since 1989, had adopted the zero burning policy so there are no direct

TABLE 11. SUMMARY OF CONVERSION OF TREE CROPS AND LOGGED-OVER FORESTS INTO OIL PALM (10^6 million ha)

Period	Oil palm (beginning)	Rubber	Cocoa	Coconut	Logged-over forest	Converted to oil palm	Oil palm (ending)
1990-94	2.029	0.099	0.122	0.023	0.139	0.383	2.412
1994-00	2.412	0.307	0.195	0.132	0.331	0.965	3.377
2000-04	3.377	0.149	0.031	0.013	0.304	0.497	3.874
Total	-	0.555	0.348	0.168	0.774	1.845	-

Sources: Statistics on Commodities 2004, Department of Statistics; MPOB.

emissions of CO_2 from this source. Malaysia being a country of free enterprise where companies which own other crops like rubber, cocoa and coconut areas are free to convert the crops to oil palm. However, under UNFCCC guidelines when these companies replanted their previous crops to oil palm under the NC2 they will have to think of how to account for the change in carbon stocks from the previous crops consisting of rubber, cocoa and coconut or from logged-over forests and peat from the pools of standing biomass. Usually, it is assumed that when the other crops are converted to oil palm they are considered as matured trees at the end of their economic life. For this, the standing biomass of shoot and root used are shown in *Table 12.*

TABLE 12. STANDING BIOMASS OF RUBBER, COCOA AND COCONUT

Crop	Standing biomass (t ha^{-1})	Carbon content (%)
Rubber	158	45.8
Cocoa	100	45.0
Coconut	100	45.0

Source: Adapted from Henson (2004).

When logged-over or ex-forested land is converted to oil palm, usually there is minimum area of high biomass forests being converted to oil palm. Normally the areas given for oil palm are logged-over forests where instead of having 350-400 t ha^{-1} of biomass in the pristine forest stage there is usually less than 100 t ha^{-1} of biomass in the logged-over stage. Assuming another 30 t ha^{-1} is removed as useable wood (more than 6 inches diameter) this quantity represents mitigation of losses from the site as the materials are removed. This leaves about 70 t ha^{-1} of debris left behind to decay as part of the soil organic matter (SOM). The residue debris, called necromass may be slow to decay and be persistent. The SOM is assumed to decline within five years.

Since zero burning had been enforced from 1989 onwards, the debris left behind can be considered as some form of sequestration and behave as a sink. As for peat that has been drained, the averaged emission is assumed to be 7.5 t ha^{-1} yr^{-1} (Henson, 2004). During the period (1995-2000) an estimated 0.05 million hectares of peat was cleared for oil palm planting.

c) Sequestration from standing biomass

To calculate the sequestration, the average standing biomass values for palms of various ages are shown in *Table 13*. The age profile of the four benchmarked years as shown in *Table 14*.

Based on the areas under the different age profiles, the standing biomass for four benchmarked years of 1990, 1994, 2000 and 2004 is calculated.

In the estimating process, the carbon content is assumed to be 40% for vegetative dry matter and higher at 57.6% for reproductive dry matter such as harvested bunches due to the higher carbon content in oil. This 57.6% carbon figure however is ignored as the developing bunches in standing palms are still not ready for harvesting. However, there are some bunches nearing maturity and the content of carbon in the oil formed should have a higher carbon content fixed.

Thus, the carbon content of biomass under two situations where there are a lot of younger palms is at 0.40% and with a lot of mature bearing palms is at 0.45% respectively. The results are shown in *Tables 15* and *16.*

The carbon storage in oil palm standing biomass in the two baseline years of 1994 (INC) and 2000 (NC2) showed the amount of carbon sequestrated by the oil palm industry. With a higher carbon content of the biomass used in the determination as shown in *Table 16*, the amounts carbon sequestered were higher by 6.072, 7.277, 11.159 and 12.997 million tonnes in all the four benchmarked years of 1990, 1994, 2000 and 2004 respectively over that shown in *Table 15.* The higher carbon content reflected the need to obtain accurate figures. Using the amount of carbon sequestered in *Table 16* the increase in carbon from 80.626 million tonnes in 1994 (being the baseline year selected for the INC) to 100.430 million tonnes in 2000 (the NC2 baseline year) is about 19.804 million tonnes. Such an increase was due mainly to the expansion in planted area from 2.412 to 3.377 million hectares - a gain of 0.965 million hectares.

TABLE 13. AVERAGE STANDING BIOMASS FOR THE VARIOUS AGE GROUPS OF OIL PALMS (t ha^{-1})

Age profile	Biomass (t ha^{-1})
1-3	14.5
4-8	40.3
9-13	70.8
14-18	93.4
19-24	113.2
25 & above	102.5

Sources: Adapted from Henson (1999); Chan (2002 a, b).

TABLE 14. AGE PROFILE BY YEAR (planted area in '000 ha)

Year	Peninsula	Sabah	Sarawak	Total
1990				
Immature 1-3	186	73	24	83
4-8	612	113	8	733
9-13	354	31	9	394
14-18	369	43	8	420
19-24	175	16	4	195
25 & above	3	0	1	4
Total	1 699	276	54	2 029
1994 (INC)				
Immature 1-3	152	85	31	268
4-8	503	220	45	768
9-13	438	74	6	518
14-18	338	35	9	382
19-24	364	38	9	411
25 & above	63	0	2	65
Total	1 858	452	102	2 142
2000 (NC2)				
Immature 1-3	213	132	90	435
4-8	278	596	188	1 062
9-13	406	139	36	581
14-18	498	71	2	571
19-24	415	41	10	466
25 & above	237	22	3	262
Total	2 047	1 001	329	3 377
2004				
Immature 1-3	237	84	103	424
4-8	371	602	301	1 274
9-13	354	251	70	675
14-18	475	126	28	629
19-24	514	81	5	600
25 & above	249	21	2	272
Total	2 200	1 165	509	3 874

Sources: Ministry of Plantation Industries and Commodities; MPOB Statistics 2005.

TABLE 15. ESTIMATED AMOUNT OF CARBON SEQUESTERED AT 10^6 t BY OIL PALM AT 40% CARBON IN VEGETATIVE BIOMASS IN THE FOUR BENCHMARKED YEARS

Age profile	1990	1994 (INC)	2000 (NC2)	2004
1-3	1.641	1.554	2.523	2.459
4-8	11.816	12.380	17.119	20.537
9-13	11.159	14.670	16.454	19.116
14-18	15.691	14.272	21.333	23.499
19-24	8.830	18.610	21.100	27.168
25 & above	0.164	11.863	10.742	11.152
Total	49.301	73.349	89.271	103.931

Sources: Adapted from Henson (1999); Chan (2002a, b).

TABLE 16. ESTIMATED AMOUNT OF CARBON SEQUESTERED IN 10^6 t BY OIL PALM AT 45% CARBON IN VEGETATIVE BIOMASS IN THE FOUR BENCHMARKED YEARS

Age profile	1990	1994 (INC)	2000 (NC2)	2004
1-3	1.846	1.749	2.838	2.767
4-8	13.293	13.298	19.259	23.104
9-13	12.553	16.503	18.511	21.506
14-18	17.563	16.055	23.999	26.437
19-24	9.933	20.936	23.738	30.564
25 & above	0.185	12.085	12.085	12.546
Total	55.373	80.626	100.430	116.924

Sources: Adapted from Henson (1999; 2004); Chan (2002a, b).

Prescribed burning of agricultural residues

a) Diseased fields

Some times when there are badly diseased fields with pests and diseases like *Ganoderma*, permission is requested to destroy the affected debris by controlled burning. The imperfect burning of agricultural residue produces emissions of CH_4, N_2O, NO_x, CO and NMVOC. As no reports on the number of fields with diseased palms actually having obtained permission from relevant authority, the emissions from burning of replanted palm debris are not considered in the final carbon balance calculation.

b) Smallholders' exemption

Smallholders are exempted from zero burning practice. As the national areas under smallholdings are small in the first instant and smaller still when it comes to annual replanting, this aspect was not considered in the calculations.

Enteric fermentation. As alluded earlier, there is enteric fermentation in domestic livestock, mainly ruminant herbivores and this has now to be considered. The production of CH_4 is part of the normal digestive process of ruminant animals and occurs in smaller amounts in other herbivores. The intensity of methane emissions will depend on the animal category, the type and amount of ingested food, the degree of digestibility of the digested mass, and the intensity of physical activities of the animal according to the different production practices. The 1996 IPCC guidelines put CH_4 emission factor for diary cattle as 57 and non-dairy cattle comprising of adult male at 57, adult female at 58 and young cattle at 42 kg head^{-1} yr^{-1}.

Table 17 provides some data of number of heads of livestock in oil palm plantations with cattle at 92% formed the major group of livestock. Assuming a stocking rate of one head/1.5 ha, the total area involved is about 450 000 hectares. The weeding cost reduction will mean less herbicides used. This indirectly will reduce GHG emissions from fossil used in the manufacture of such herbicides (*Table 7*).

TABLE 17. NUMBER OF RUMINANT AND HERBIVORE GRAZING POPULATION IN OIL PALM ESTATES

Year	Buffaloes	Cattle	Sheep	Goats	Total
1990	12 900	61 500	14 000	10 000	98 400
1994 (INC)	10 500	67 600	13 000	13 400	104 500
2000 (NC2)	8 800	242 600	10 000	6 700	268 100
2004	6 400	271 500	8 500	7 500	293 900

Source: Rosli Awaluddin (pers. comm. 2005).

Using the CH_4 emission figure of 58 kg head^{-1} yr^{-1} for buffaloes and cattle, and 42 kg head^{-1} yr^{-1} for sheep and goats, the total amount of CH_4 emitted is shown in *Table 18*.

It can be seen that in 1994 the emissions from enteric fermentation totalled 0.006 million tonnes was exceeded in 2000 by 2.5 times to 0.015 million tonnes of CH_4. As CH_4 has 21 times the global warming potential (GWP), this figure was factored into the calculation. Overall the amount emitted by the livestock population is still small.

TABLE 18. CH_4 EMISSIONS FROM LIVESTOCK MANAGEMENT IN PLANTATIONS (10^6 t yr^{-1})

Category	1990	1994 (INC)	2000 (NC2)	2004
Buffaloes	0.00075	0.00061	0.00051	0.00037
Cattle	0.00356	0.00392	0.01407	0.01575
Sheep	0.00059	0.00055	0.00042	0.00035
Goats	0.00042	0.00056	0.00028	0.00032
Total	0.00532	0.00564	0.01528	0.01679
CO_2 e @ 21 x GWP	0.11172	0.11844	0.32088	0.35259
C emissions	0.0304	0.0323	0.0875	0.0962

The integration of livestock and use of buffaloes/cattle as draught animals for in-field transport of FFB is limited. However, the practice with wider adoption should lead to a reduction of emissions from fossil fuel that is used to drive vehicles and machinery in the field. As the practice of using draught animals was popular previously in Sabah estates and also in PAMOL estate in Kluang, there is a need to re-look at the reasons why it is still not wide spread. Perhaps the other benefits of livestock integration include reduced weeding cost, lower herbicide use, recycling of nutrient, improved soil organic matter and increased yield of oil palm together with increase in protein production should be highlighted. Against all these are production of CH_4 and CO_2 and the possibility of soil compaction.

Nitrous oxide (N_2O) emissions from agricultural soils

a) Emissions from manure management

The N_2O emissions from manure management to be considered since livestock integration is adopted in an effort to produce protein using the agroforestry concept in the same land where oil palm is grown is used for livestock integration. Manure management is responsible for emissions of CH_4 and N_2O. In the plantations, most of the livestock is on range - land management with little need for anaerobic treatment ponds. Anyway the area estimated at 450 000 ha is small when compared to the total oil palm area.

b) Emissions from nitrogenous fertilizer applications

There is also some N_2O emitted directly from agricultural soils results from application of nitrogenous fertilizers such as synthetic fertilizers like sulphate of ammonia with 0.8% N_2O emissions, urea (1.1%), ammonium nitrate (1.7%), ammonium chloride (0.1%) and also of animal origin by the manure (0.7%) deposition in the fields as stated earlier. The latter is an important consideration due to the increasing number of heads of cattle in the future.

Assuming that the bulk of the nitrogenous fertilizers is sulphate of ammonia at 50% followed by urea at 18%, ammonia nitrate at 15% and ammonium chloride at 17% the amount of N_2O emitted directly is shown in *Table 19.*

Nitrous oxide can come from various activities besides agricultural practices of manuring using nitrogenous fertilizers and they include industrial processes, fossil fuel combustion and forest conversion to other uses. As most of the N_2O with 290 GWP comes from agriculture, this is accounted for in *Table 19*.

Emissions from N_2O in the energy sector comes from imperfect fuel sector while in the industrial processes, it comes from production of nitric acid, in the land-use and land-use change, and forestry sector it comes from biomass burning.

TABLE 19. QUANTITY OF N_2O EMITTED IN 10^6 t ha^{-1} yr^{-1} FROM NITROGENOUS FERTILIZERS APPLIED AT 3 kg $palm^{-1}$ AT 148 palms ha^{-1} OVER THE FOUR BENCHMARKED YEARS EXPRESSED AS CO_2 EQUIVALENT AT GLOBAL WARMING POTENTIAL (GWP) OF 290 AND AS C EMITTED

Fertilizers	Usage (%)	Emission factor (%)	1990	1994	2000	2004
Area (10^6 ha)	-	-	2.029	2.412	3.377	3.875
$(NH_4)_2 SO_4$	50	0.8	0.0036	0.0043	0.0060	0.0069
Urea	18	1.1	0.0018	0.0021	0.0030	0.0034
NH_4NO_3	15	1.7	0.0023	0.0027	0.0038	0.0044
NH_4Cl	17	0.1	0.00015	0.00018	0.00025	0.00029
Total N_2O emissions	-	-	0.00785	0.00928	0.01305	0.01499
CO_2 e @ 290 GWP	-	-	2.3925	2.6912	3.7845	4.3471
C emissions	-	-	0.621	0.733	1.032	1.1855

Emissions from crop residues left in the field as mulch and from composting. In addition from the production of carbohydrate through crop integration, the crop residues from say dry land paddy, sorghum, yam and banana are not burned but used as mulching material for oil palm. Since no flooded paddy is cultivated, one of the principal sources of CH_4 emissions is eliminated from the computation. However some companies practise empty bunch composting and there is generation of CH_4 to be considered. Quantification of CH_4 capture will have to be made if the practice becomes widespread.

Land-use and land-use change and forestry (LULUCF)

Between 1994 as the base year used for computation of national emissions and removals for the INC submission in 2000, and 2000 as the base year for NC2 for computation of emissions and removals for submission in 2006, there are changes in land area use under oil palm.

Forest conversion to agricultural activities: emissions from biomass of previous crops and logged-over forests. Loss of biomass involving the clearing of oil palm has been factored into the oil palm standing biomass in *Table 16*.

However, as shown in *Table 11*, between 1990-1994, there were increases in area coming from 0.099, 0.122 and 0.023 giving a total of 0.244 million hectares coming from rubber, cocoa and coconut respectively. The balance of 0.139 million hectares was assumed to come from logged-over forests to make up the total of 0.383 million hectares of new oil palm area. Losses of biomass from these ex-tree crops and from logged-over forests (of which 0.100 million hectares of the latter group) were assumed to come from peat forests as shown in *Table 20*.

TABLE 20. CARBON EMISSIONS (10^6 t yr^{-1}) ARISING FROM AREAS USED FOR OIL PALM EXPANSION FROM PERIODS OF 1990 TO 1994 (INC) AND 1994 TO 2000 (NC2)

1990-1994	Rubber	Cocoa	Coconut	L.O. forest	Peat	Total
Total area (10^6 ha)	0.099	0.122	0.023	0.129	0.010	0.383
Annual area (10^6 ha)	0.025	0.031	0.006	0.032	0.0025	0.095
Standing biomass (t ha^{-1} yr^{-1})	158	100	100	100	100	-
% removed as wood	60	0	0	30	30	-
% carbon in wood	45.8	45.0	45.0	45.0	45.0	-
Estimated C emitted (10^6 t^{-1} yr^{-1})	0.716	1.373	0.259	1.016	0.079	3.443
C emitted by peat (10^6 t^{-1} yr^{-1})	-	-	-	-	0.188	0.188
Grand total C emitted (10^6 t yr^{-1})	-	-	-	-	-	3.531
1994-2000	**Rubber**	**Cocoa**	**Coconut**	**L.O. forest**	**Peat**	**Total**
Total area (10^6 ha)	0.307	0.195	0.132	0.269	0.062	0.965
Annual area (10^6 ha)	0.051	0.033	0.022	0.044	0.010	0.161
Standing biomass (t ha^{-1} yr^{-1})	158	100	100	100	100	-
% removed as wood	60	0	0	30	30	-
% carbon in wood	45.8	45.0	45.0	45.0	45.0	-
Estimated C emitted (10^6 t^{-1} yr^{-1})	1.481	1.462	0.990	1.412	0.326	5.671
C emitted by peat (10^6 t^{-1} yr^{-1})	-	-	-	-	0.271	0.271
Grand total C emitted (10^6 t^{-1} yr^{-1})	-	-	-	-	-	5.942

Sources: Adapted from Henson (2004).

Similarly in *Table 11*, between 1994 INC and 2000 NC2, the increases in oil palm areas came from 0.307, 0.195 and 0.132, giving a total of 0.634 million hectraes coming from rubber, cocoa, coconut respectively. The balance of 0.331 million hectares was assumed to come from logged-over secondary forests to make up the total oil palm area of 0.965 million hectares. However the losses of biomass involving planting from ex- rubber, cocoa, coconut and logged-over forests (of which 0.0622 million hectares is estimated to come from peat) have to be accounted for, as shown in *Table 20.*

i) Rubber. The standing biomass is estimated to be 158 t ha^{-1} yr^{-1} (vide *Table 12*) of which 60% is harvested as rubberwood and removed from the site. The remaining 40% especially the rubber boles were left to decay and form part of the soil organic matter in which eventually disappears as CO_2 emissions.

ii) Cocoa and coconut. As no wood is taken away, the debris amounting to 100 t was allowed to decay as soil organic matter in which eventually disappears as CO_2 emissions.

iii) Logged-over (L.O.) forests. A further 30% of the wood is harvested as usable wood while the remainder 70% was allowed to decay as soil organic matter in which eventually disappears as CO_2 emissions.

iv) Peat. A 30% of wood is harvested from the peat forest while 70% were allowed to decay as soil organic matter in which eventually disappears as CO_2 emissions. There is also an annual emission of carbon emitted from the cultivated peat estimated to be 7.50 t ha^{-1} yr^{-1} as the peat is drained (Henson, 2004). The calculation would involve the area divided by the numbers of years to get the annual area and that the debris from each annual area would disintegrate by the fifth year. The first year estimate would cover the annual area of peat loss of CO_2 oxidized and the second year would involve double the annual areas, the third year tripled the annual areas and so on till the fifth year where the total area five times the annual area. At the sixth year, the total area becomes six times the annual area.

The deforestation of native vegetation has been dealt with under Zero Burning section. In fact, changes in carbon stocks have to be accounted for by the respective agricultural crops when logged-over forests or deforested land are converted to crops such as rubber, cocoa and coconut before they are eventually converted to oil palm. This includes deforestation where there are emissions of CO_2 to the atmosphere. The increase in areas could come about from conversion of rubber, cocoa, coconut, other perennial fruit crops, pastures and from logged-over forests is seen earlier in *Table 17*. Forest re-growths on the other hand can come either from abandonment of marginal steep land reconverted into forest or replanted in high density planting oil palm agro-forest grown mainly to harvest for biomass production. In both instances, they imply removal of CO_2 from the atmosphere through sequestration. With growing importance of fibre from palm biomass for use in various products and as fuel, the amount sequestrated and the saving of fossil fuel usage will feature prominently in subsequent compilation of carbon balance.

Changes in carbon content of soils. As a result of land use changes, such as forest conversion to agricultural land, and introduction of inter-crops/livestock integration can affect GHG emissions. Such type of changes on emissions and removals will depend on a number of factors:

- the type and use of soil management practices;
- the application of fertilizers to enhance soil fertility;
- the conversion of organic soils such as peat to agriculture or oil palm;
- the maintenance of the water table where if it is not well managed will cause a rapid oxidation of organic matter;
- the monitoring of changes in carbon associated with CO_2 emissions and its removals from soils through cultivation; and
- on-site burning of thick forest biomass or diseased debris in replants must be recorded and quantified.

Sinks in oil palm plantings. This represents an industrial agro-forest development that is on an expanding activity in this country. This usually results in an increase in biomass stock in standing palms in which they are recorded as sinks (vide *Table 16).*

Here there are CO_2 emissions and removals at the same time but with a predominance of the latter. This includes ground vegetation in oil palm plantations, frond piles, biomass from felled palms/ex-tree crops and forest at the initial years of replanting. Through out the discussion a 25-year replanting cycle is assumed for replanting. The quantities of biomass from ground vegetation from legumes and indigenous flora, pruned fronds left in piles, debris at time of felling for replanting to oil palm are shown in *Table 21*.

Due to zero burning they represent partly as sequestration decaying over a five-year period, yet there are emissions as the decay occurs.

TABLE 21. BIOMASS C IN GROUND VEGETATION, PRUNED FRONDS AND FELLED PALMS (10^6 t yr^{-1})

Sinks in oil palm plantings	1990	1994 (INC)	2000 (NC2)	2004
Ground vegetation	2.492	3.628	4.519	5.262
Pruned oil palm frond piles	3.156	4.596	5.725	6.665
Felled oil palm material	2.879	4.193	5.222	6.080
Total	8.527	12.417	15.466	18.007

Source: Adapted from Henson (2004).

i) Ground vegetation. Henson (2004) found that the mean carbon sequestered annually by ground vegetation over the period 1991-2000 on a 25-year replanting cycle to be 0.208 million tonnes and this represented only about 4.5% of that stored in the standing biomass of the oil palm as shown in *Table 16.*

ii) Frond piles. As for the frond piles, they represented the largest amount when compared with spent male inflorescences, bracts, uncollected loose fruits, frond butts (from older palms) and rotten bunches. For example, the spent male inflorescences is around 0.5 t ha^{-1} when compared with pruned frond biomass of 14.5 t ha^{-1} (Chan *et al*., 1981). Initially the number of fronds produced may be higher up to three fronds produced/month but once matured the number of fronds are held stable at two/month. Here it was found by Henson (2004) that the rate of sequestration to be 0.263 million tonnes over the period 1991-2000 on a 25-year replanting cycle. This was about 26% more than that of ground vegetation and therefore assumed to be 5.7% of the standing biomass (vide *Table 16*).

iii) Biomass material from felled palms at replant. Here Henson (2004) calculated the total biomass of felled palm material and with their decay constants for leaflets, rachis, trunk and roots calculated the remaining biomass and carbon content present for the remaining years. He found that the rate of sequestration was 0.240 million tonnes over the period 1991-2000 on a 25-year replanting cycle. This was equated to be 15% more than the ground vegetation and therefore assumed to be 5.2% of the standing oil palm biomass (*Table 16*).

iv) Sequestration in non-oil palm material from felled tree crops and ex-logged over forests. The sequestration here usually refers to the establishment of new oil palm planting through the replacement of other three crops and logged-over forests. This has been accounted for in *Table 20*.

Waste

In the oil palm industry, the recycling of solid waste such as 80% of empty fruit bunches back to the field does not create any problem of methane. However, if composting is contemplated than there is consideration for quantifying CH_4 if the practice becomes wide spread.

Empty fruit bunches (EFB) for mulching. As 80% of the EFW is currently recycled as mulch, there is saving in fertilizers. However, there is a cost of about RM 13 for each tonnes of EFW returned the economics needed to be recalculated especially when fossil fuel is used in transport of EFB. However, for the purposes of calculating the carbon balance in *Table 23* the total amount of EFB is ultimately considered as a source of emission whether it is combusted or used for mulching in the field. It however affects the soil organic carbon if it is used as mulch. Of course the economics will change due to the saving in mineral fertilizers.

Composting of solid waste creates anaerobic conditions. When there is an increase in activity of composting of empty fruit bunches with use of effluent, such a practice creates anaerobic conditions that generate CH_4. The potential of this gas increasing will depend on the control conditions in the process. Efforts should be made to capture CH_4 under enclosed condition as a biogas to be used as a fuel.

Capturing CH_4 in effluent ponds. Effluents in retention ponds with high degree of organic content when undergoing commercial waste treatment through the effluent pond system where the effluent is digested under anaerobic conditions has a high potential as a source of production of methane. The quantities of potential CH_4 to be captured as a source of biogas from effluent ponds are estimated in *Table 8*.

Again the current research to trap the CH_4 is being experimented in CDM projects and until more results are available, the estimate as in *Table 8* will suffice.

*Application of POME as a mineral fertilizer substitute***.** The effluent is rich in nutrients. As 70% of the POME is recycled to the fields there is a considerable saving in mineral fertilizers to those field applied with POME. However, there is a cost for application of the POME back to the field as a fertilizer substitute. For the purpose of calculation of the carbon balance the quantity of POME recycled as fertilizer substitute is estimated under *Table 8* as part of the capture of CH_4.

Oil palm mill products

Malaysian palm oil and other mill products are exported and consumed within the year by the importing countries. Usually palm oil, palm kernel oil and palm kernel cake, oleochemicals and palm oil products are exported. The total amount of carbon exported for the four benchmarked years are shown in *Table 22*.

Oils and fats are an important part of the human diet and act as the calorie-dense components. Each gramme of oils and fats provides 9 kilocalories (kcal) of energy, compared with 4 kcal g^{-1} from carbohydrates and proteins.

As palm oil is exported as a source of energy in food sector and as 90% is exported, the COP 11 meeting in Montreal, Canada in December 2005 must decide on the ownership of the harvested product whether the carbon should belong to the producers or importers. Malaysia utilizes 10% of the palm oil product produced and has to account for it. Anyway for the purpose of the calculation of the carbon balance all the 100% carbon is placed under the energy sector as part of sequestration.

THE CARBON BALANCE FOR THE PALM OIL INDUSTRY

The estimated mean annual carbon emissions and carbon sequestration in Malaysian palm oil industry over the two INC and NC2 benchmarked years are shown in *Table 23*.

The overall balance of 126.411 million tonnes in 2000 showed that the oil palm is a net sequester of carbon. Once oil palm is planted, over the next 25 years, the field will see a progressive increase in carbon build-up. This included the export of carbon in palm oil products as a food energy source. The biomass C emissions and stocks are shown in *Table 23*.

The values quoted in *Table 23* represents a snap shot of the carbon emissions and sources in the benchmarked years of 1994 and 2000. What we need to know is not the stock but the fluxes and for this we need to know the trend. This is because individual years' values are not adequate to understand sequestration due to the year-to-year variations but rather we should look at medium- to long-term trends covering one or two decades respectively. Preferably sequestration should be quantified after stabilization of the clearing and replanting activities. Further, we do not have measurements of sequestration of samples of individual fields undergoing clearing and replanting at the moment to build up the database.

As *Table 23* carries some figures that are cumulative, *e.g.* standing biomass and some are on individual years' basis, *e.g.* energy for production of inputs for production, the figures need to be streamlined. By right the net figure in sequestration rather than the biomass C stock will have to be pooled to offset the overall national emissions figure where other industries including the transport industry will require the net balance not only from the oil palm industry but also the forestry and other tree crops industries which acted as sinks to reduce the emissions from manufacturing and other industrial processes.

Thus, although UNFCCC quantification tend to look at the gross figure as a snap shot over the benchmarked years, a preliminary assessment of the emissions and sequestration on an annual basis, over the periods 1990-1994 and 1994-2000, are shown in *Table 24*.

TABLE 22. QUANTITY AND CARBON CONTAINED IN MALAYSIAN OIL PALM MILL PRODUCTS (10^6 t yr^{-1})

Oil palm mill products	1990	1994 (INC)	2000 (NC2)	2004
Palm oil	6.095	7.221	10.842	13.98
Palm kernel oil	0.827	0.978	1.385	1.60
Palm kernel cake	1.038	1.223	1.639	1.89
Total products	7.960	9.422	13.866	17.47
Carbon content of mill products				
Total carbon in palm oil @75% C	4.571	5.146	8.132	10.485
Total carbon in kernel oil @72% C	0.595	0.704	0.997	1.152
Total carbon in kernel cake @60% C	0.623	0.774	0.983	1.134
Total carbon in palm products	5.789	6.624	10.112	12.771
Total carbon in the 90% exported	5.210	5.962	9.101	11.494

Source: Adapted from Henson (2004).

TABLE 23. BIOMASS C EMISSIONS AND STOCKS (10^6 million tonnes)

Source	1994 (INC)	2000 (NC2)	Notes
Energy			
Energy for direct and indirect inputs for production	1.705	2.386	*Table 7*
Industrial process			
90% CH_4 in biogas	0.036	0.053	*Table 8*
Agriculture			
Enteric fermentation	0.032	0.088	*Table 18*
Nitrous oxides from N fertilizers application	0.733	1.032	*Table 19*
Waste			
Accounted for in *Table 8*			
Land-use, land-use and forestry			
Expansion from ex-crop and logged-over forests	1.160	2.407	*Table 20*
Total emissions	3.666	5.966	-
C stock			
10% biogas used with offset against diesel use	0.004	0.006	*Table 8*
Fibre, shell and EFB (20%) as fuel to offset diesel use	0.126	0.188	*Table 8*
EFB (80%) used for mulching	0.134	0.202	*Table 8*
Energy efficiency to offset diesel use	0.005	0.007	*Table 9*
C in standing biomass	80.626	100.430	*Table 16*
C in ground vegetation and debris	12.417	15.466	*Table 21*
C in biomass of mill products	6.624	10.112	*Table 22*
Total C stock	99.936	126.411	-

TABLE 24. PRELIMINARY ASSESSMENT OF THE EMISSIONS AND SEQUESTRATION TO DEVELOP THE CARBON BALANCE SHEET (10^6 t yr^{-1})

Source	1994 (INC)	2000 (NC2)	Mean annual change	Notes
Emissions				
1. Energy				
Energy for direct and indirect input for production	1.705	2.386	2.046	*Table 7*
2. Industrial process				
90% CH_4 in biogas	0.036	0.053	0.045	*Table 8*
3. Agriculture				
Enteric fermentation	0.032	0.088	0.060	*Table 18*
Nitrous oxide from nitrogenous fertilizers	0.733	1.032	0.883	*Table 19*
4. Waste				
Accounted for				*Table 8*
5. Land-use, land-use and forestry				
Expansion of new areas ex-crop and logged areas	1.160	2.407	5.942*	*Table 20*
6. Total emissions: 1-5	3.666	5.966	8.976	
Sequestration				
7. 10% CH_4 used as biogas	0.004	0.006	0.005	*Table 8*
8. Renewable energy as carbon offset from fibre shell and EFB	0.260	0.390	0.325	*Table 8*
9. Energy efficiency as carbon offset	0.005	0.007	0.006	*Table 9*
10. Standing biomass	3.546	1.882	3.301*	*Table 16*
11. Sinks	0.546	0.290	0.508*	*Table 21*
12. Palm oil products	-0.105	0.258	0.581*	*Table 22*
13. Total sequestration: (7-12)	4.256	2.833	4.726	-
14. Net sequestration: (13)	0.590	-3.133	-4.250	-

Note: *Mean value 1995-2000 inclusive.

This is a first attempt to fit the carbon balance in the palm oil industry along the UNFCCC National Communication framework under the NC2. It is an improvement over the INC as several areas of improvements notably the emissions of methane from enteric fermentation from livestock and of nitrous oxide from nitrogenous fertilizers application had been factored into the calculation of carbon balance. No doubt the methane capture from effluent ponds would be added once the full technology, currently under CDM research investigation becomes a routine practice. Likewise the potential saving of C from the biodiesel project as outlined in *Table 10* of savings of up to 0.351 million tonnes carbon from converting 500 000 t palm oil through the biodiesel project for producing B5 biofuel would be included.

The preliminary assessment will need to be refined as more R&D results are available. Be as it may there is a need to look at way of reducing emissions by raising higher productivity per hectares rather than going for increase area of production as there is a need to account for the emissions from logged-over forests and peat will have additional emissions yearly to be accounted for from oxidation. Alternatively there is a need to have higher yielding planting materials planted together with resource use efficiency through greater recycling of biomass.

Adaptation Improvement

In accordance with the principle of common but differentiated responsibilities, only countries included in Annex I of the UNFCCC must establish measures in order to reduce GHG emissions targets. Despite the fact the developing countries are not required to limit the global emission, Malaysia as stated earlier (though a developing country which is bound to increase its global emission when its needs to achieve social and economic development to be a developed nation) has decided to find ways to reduce its GHG emissions. Efforts are in place through a two-pronged approach firstly, to reduce such emissions and secondly, to increase removal through sequestration as the country wants to contribute to the ultimate objective of the UNFCCC.

Information presented in the INC was based on the knowledge, experience and expertise where no empirical research was done that could have provided more accurate data to further confirm the results. Within the INC, the vulnerability in the agriculture sector was assessed by the effects on effects of climate change on yield of major economic crops like rubber, oil palm cocoa, and rice. The great difficulty was due to the lack of data for model simulation. Some of the country's adaptation initiatives would include:

- use of renewable *clean* energy sources, as mentioned earlier, with low levels of GHG emissions per unit of energy produced or consumed;
- reduce use of fossil fuels through improved energy efficiency;
- increase carbon stock through carbon sequestration by planting the abandoned land with high-density oil palm spacing;
- programme related to sustainable development to be emphasized: one of the programmes is to convert the excess palm oil into biodiesel. Three grades of biodiesel are proposed where biodiesel can substitute up to 2%, 5% or 10% designated as B2, B5 and B10 biofuels. In the case of B5 by substituting fossil fuels say up to 5% for a start, the amount of CO_2 emissions avoided annually can be substantial (vide *Table 10* for reduction in CO_2 e.). Thus, the oil palm industry can help to contribute to the energy sector in reducing the CO_2 emission;
- another programme is to promote the adoption of more energy efficient technologies and contribute the excess energy from the oil palm mills to the national electricity grid. In this way, the potential electricity generated surplus to the mill energy requirement is channeled to the national electricity grid;
- promotion of R&D into green energy;
- improve the capacity training;
- improve systematic scientific observation related to climate change modeling; and
- strengthen collaboration in the areas of climate change education, training and public awareness.

Mitigation Measures

In the INC, it was reported that the mitigation options were from energy, industrial, agriculture, land-use and land-use change, forestry and from waste. With NC2 however, policies and measures to reduce GHG emissions are to be detailed for the energy, agriculture, waste, land-use change and forestry sector.

- In the energy sector, on the supply-side, the renewable energy options would be considered. On the demand-side, energy conservation and EE should be highlighted;
- In the agriculture sector, improving farming and animal husbandry though LULUCF good practice should be adopted;
- In the waste sector, there is a need to minimize waste, recycle and improve waste management process;

- In LULUCF reduction in rate of deforestation, increase in afforestation, increase in efficient use of biomass fibre and increase in soil carbon retention; and
- Consider CDM projects to raise level of R&D and to transfer technologies to Malaysia.

The rapid economic growth expected in Malaysia will result in more rapid growth and demand of energy. The demand in energy is expected to grow in order to meet the demands of rising standards of living.

While the growth in demand for fossil fuel will mainly be driven by transportation and industry, the demand for electricity generation may increase up to 5% be mitigated by renewable energy from the biomass, biofuel and biogas from the palm oil industry. Thus, the emissions can be expected to rise with the future economic growth yet the palm oil industry could play its role here to reduce emission with its renewable energy sources.

Certainly the oil palm industry is working hard to reduce GHG emissions not only by using the excess renewable energy but also into energy efficient processes. The present effort to capture the methane from the effluent ponds using the enclosed tanks is definitely in the right direction. Further the sequestration in the standing biomass will be better quantified and policies programmes to adopt good agricultural practice will help in addressing global environmental challenges.

DISCUSSION

This work forms part of the Ministry of Plantation Industries and Commodities, Malaysia's national effort in collaborating with policy makers of other numerous ministries in their involvement in the preparation of Malaysia Second Communication for submission to UNFCCC by end of 2006.

The adaptation and mitigation R&D efforts discussed here on measuring and evolving local emissions factors are manifestations of the seriousness of the industry in contributing towards a better assessment of growing evidence to improve our knowledge on emissions and sequestration.

The framework here requires sensitivity tests as done by Henson (2004) using different ages of replanting at 20, 25 and 30 years so as to capture all situations and to improve the risk management.

For the future, the different scenario paintings, as done by Yusof and Chan (2005), will enable us to look at what are the crucial factors to consider when zooming into the actual new data to capture that arise from this analysis. No doubt more and more accurate figures will be forthcoming with further R&D inputs, *e.g.* CH_4 emissions figures from effluent ponds and better prediction of climate change with models to be developed and improved together with their predictability.

CONCLUSION

The Malaysian palm oil industry does and will continue to contribute to the nation and global efforts to mitigate climate change by limiting its future emissions domestically by reducing use of fossil fuels through use of renewable energy from its plentiful biomass fibre, methane capture to generate biogas and substitute fossil fuels by using biofuels. The imperatives for which are for local, national and global priorities to be set for medium and long terms over 10 to 20 years respectively to obtain better trends of sequestration accompanied with better measurements of local emission factors.

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