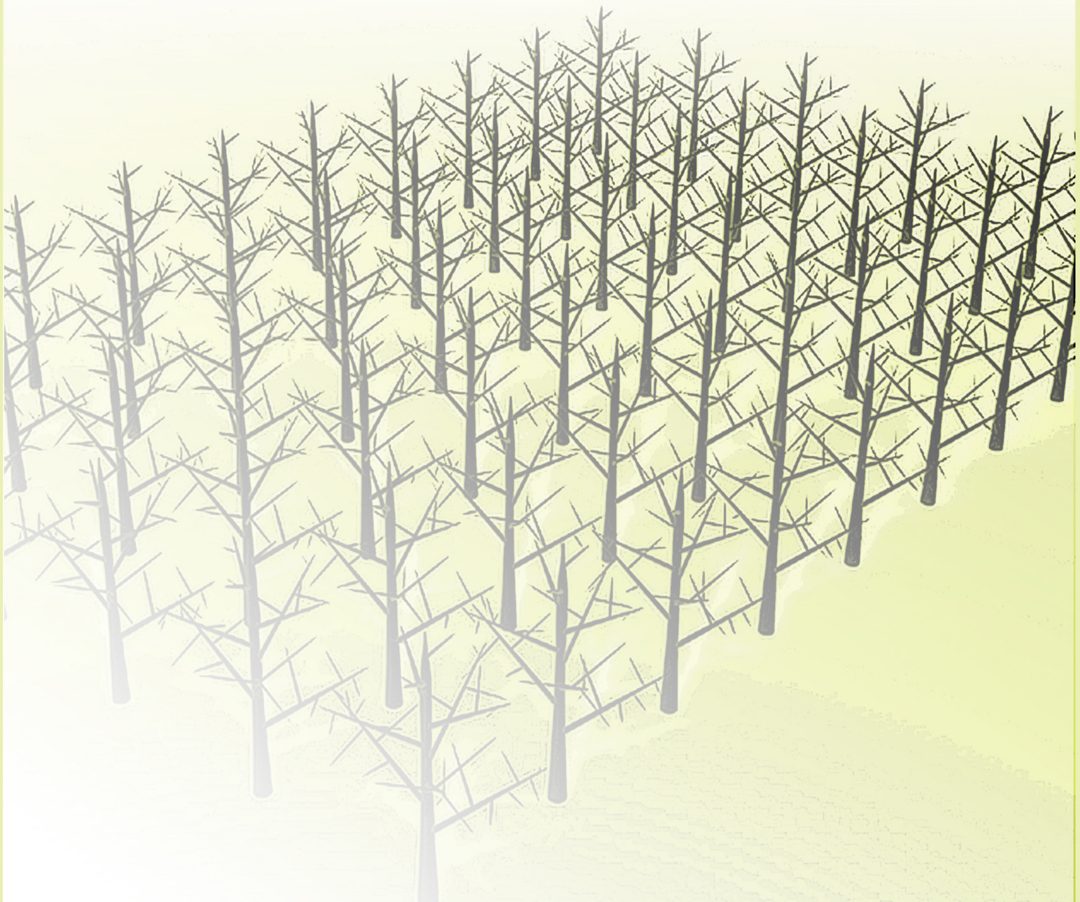
Controversies of Minister of Agriculture Regulation No.14 of 2009

Based on data and facts discussed above, it is known that palm oil plantation planted on mineral soil for 25 years able to absorb 130 tonnes of CO2 eq/ha or if vary, the value will not be more than 180 tonnes of CO2 eq keeping in mind that the above ground carbon storage on palm oil plantation in Tanah Grogot is 39.94 tonnes / ha or equal to 146.58 tonnes of CO2 eq./ha.

The realistic GHG emissions and drained peatland is 25-55 tonnes of CO2-eq/ha/year or equal to 625-1375 tonnes of CO2-eq for 25 years. While for Imperata cylindrica area on depth of 0-30 cm the total carbon storage is a little bit lower than the ex-logging and ex-burned areas, that is 252.855 tonnes/ha or equal to 927.98 tonnes of CO2 eq./ha.



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Development of Palm Oil Plantation Based on Greenhouse Gases: Critical Perspectives

2009

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SAWIT WATCH

Development of Palm Oil Plantation Based on Greenhouse Gases: Critical Perspectives

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Foreword

The strong will to save the Earth from global warming and climate change that have negative impacts on human beings, is a wise and noble thing to do, thus should be supported through the implementation of real field activities. The efforts to save environment require agreements from many parties, especially world's leaders to really carry out their commitments without any doubts since this is associated with people's lives.

The publication of this book entitled "Development of Palm Oil Plantation Based on Greenhouse Gas: Critical Perspectives" is a simple effort to raise the problems of global warming and climate change due to palm oil expansion. This book talks about the background and impacts of increased greenhouse gases in Indonesia that have contributed to global warming due to palm oil expansion on peatlands that caused the carbon storage of peatland to break open. This book also discusses the impacts of palm oil sludge industry in increasing global warming. This is further worsened by the controversies of Minister of Agriculture Regulation No. 14 of 2009 that allows peatlands to be converted into palm oil plantations.

This book is expected to provide new insights and better understanding on the efforts to save the environment with regard to palm oil establishment on peatlands.

Bogor, August 2009

Sawit Watch

CONTENT

TERMINOLOGIES AND ABBREVIATIONS:

1. Fire is the rapid release of heat energy stored in plants through photosynthesis process.
2. Smoke is the collection of solid and soft particulates emitted from incomplete burning of carbon and other flammable materials.
3. Fuel is living or dead vegetation found above or below ground that have the potentials to cause fire.
4. Ground fuel is fuel that lies below the ground, such as peat.
5. Living fuel is fuel found within forest originated from living plants.
6. Dead fuel is fuel found within forest originated from dead plants (part of plants).
7. Above ground fuel is fuel found on forest floor (surface).
8. Crown fuel is fuel found between crowns of ground cover and trees.
9. Available fuel is parts of the whole fuel that can burn under certain condition.
10. Forest and land fires prone areas are areas identified as having high forest and land fire incidents.
11. Forest and land fires early detection are activities for early detection of forest and land fires so that prevention measures can be accurately taken and can be conducted immediately before further spread of fire.
12. Organized detection is detection that is carried out with organization and specificity.
13. Forest is an ecosystem unit comprising of natural resources that are dominated by trees and interrelated environmental elements.
14. Natural forest is forest comprising of naturally grown trees.
15. Conservation forest is forest that is design for the protection of wildlife and their habitats, often found within national parks and other conservation areas.
16. Conversion forest is forest that is design (with Timber Utilisation Permits (*IPK*)) for land clearance and permanent conversion to other forest land use, especially for wood industries or plantation.
17. Protection forest is forest with main role to regulate environmental functions, especially for the maintenance of vegetation cover and soil stability on steep slopes and to protect stream flow areas.
18. Plantation forest is forest that is established to increase the potentials and quality of production forest with the application of intensive silviculture.
19. Forest area refers to particular area determined or designated by the government as permanent forest.

20. Natural fire is fire caused by natural causes such as thunder.
21. Ground fire is a fire incident that consumes organic matters found below the soil.
22. Forest fire is a condition where fire occurs on forest and damage the forest or forest products causing economic loss as well as loss of science development and or values of living environment.
23. Land fire is a condition where fire occurs on land causing economic loss a s well as loss of science development and or values of living environment.
24. Alertness is an effort to anticipate forest and land fires through the organization of appropriate and beneficial steps.
25. Land is an area outside forest, whether vegetated (*Imperata cylindrica*, shrubs, cultivated crops, trees etc) or non-vegetated that is intended for the development of agriculture, plantation, forestry, mining etc.
26. Mitigation refers to activities that stops or reduce negative known effects of forest and land fires on human beings and environment.
27. Combustion is a burning process where there is a dependent and controlled spread of flame.
28. Land clearing without the use of fire is a land preparation activity that is carried out without the use of fire.
29. Imaging is the process of transforming data into information.
30. Fire control is an activity comprising of preventing, extinguishing and post fire management
31. Land preparation is a land clearing activity that is conducted prior to planting activities
32. Land/vegetation coverage is the surface condition of Earth that illustrates the coverage of land/vegetation.
33. Early warning is information on the occurrence of forest fire in a particular time and area.
34. Plantation is a form of agriculture that is carried out intensively by developing plants with multiple harvests.
35. Shifting cultivation is a non-permanent form of agricultural activity by following rotations for certain periods from one rotation to another.
36. Forest mapping is the process of preparing a map consited of forestry data collection, processing and presentation.
37. Remote sensing is an acquisition of information of an object, area or phenomenon through data analysis by the use of a variety of devices without direct contact with the studied object, area or phenomenon.

38. Map is a visual representation of Earth's surface on a flat plain, drawn with certain projections and scale depicting natural and man-made elements and other required information.
39. Radiation describes any process in which energy emitted by one body travels through electromagnetic wave to be absorbed by another body without any contact.
40. Fire spot is a warning/information of a fire incident on particular coordinates and latitudes.
41. Hot spot is a warning/information of an increase temperature based on satellite information.
42. Global warming is the increase n the average temperature of Earth's atmosphere, sea and surface caused by heat accumulation in the atmosphere due to greenhouse gases.
43. Not all solar radiation in the form of long wave that is reflected back to the Earth can passes through the atmosphere where some will be absorbed by gases within the atmosphere known as the Greenhouses Gases.
44. Greenhouse effect illustrates the similar process happening in the actual green house.
45. Increase of Earth's average temperature will in time cause a change of climatic elements, such as change in rainfall pattern and air pressure, increased evaporation in air or change of sea water temperature etc. As a whole, these are known as climate change.
46. United Nation Frame Work Convention on Climate (UNFCC) defines climate change as a change of climate that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and that is in addition to natural climate variability observed over comparable time periods (IPCC, 2007).
47. Water vapour is the main greenhouse gas that occurs naturally such as water evaporation from sea, lake and river and is responsible for most of the greenhouse effect.
48. Carbon dioxide is the release of gases to the atmosphere during the combustion of fossil fuels, solid wastes, and wood to heat buildings, generate vehicles and produce electricity.
49. Methane is the simplest hydrocarbon in the form of gas. The concentration of methane in the atmosphere is 1.7 ppm, where it is almost 2.5 times higher that its concentration 300 years ago. Methane in the atmosphere is assumed to have a life span of 10 years. Methane is the principal component of natural gas and is an effective insulator that can trap about 20 times the heat of carbon dioxide.

50. Nitrous oxide is mainly produced during fossil fuels combustion and from agricultural land. The life span of NO_2 in the atmosphere is 150 years.
51. Carbon calculation is the process of estimating the amount of carbon found on different parts of a system. Each tree has different ability in absorbing carbon due to the particular ability to absorb sunlight, different water content and soil fertility which all affect the rate of photosynthesis.
52. Photosynthesis is defined as the conversion of CO_2 and H2O into sugar using chlorophyll and the energy from sunlight. Photosynthesis is the assimilation of carbonic compounds where organic compounds such as CO_2 and H_2O are converted into $C_6H_{12}O_6$ molecule using the energy from sunlight and chlorophyll.
53. Peatland is an area formed from an accumulation of partially decayed dead ancient plant materials, comprising of a minimum of 12-18 % C-organic with minimum depth of 50 cm. Peat has double meaning, as an organic material (peat) and organic soil (peat soil). Peat and peat soil have different functions. Peat as organic material is source of energy, medium for plant growth or organic fertilizer, while peat as organic soil is used for agricultural purposes and can be manage within agricultural system.
54. Peat has irreversible drying property, meaning upon drying, the peat will not returned to its original state (similar when the peat is burned, it will not go back to its original form due to the damaged peat).
55. Topogenous peat is often found in swamp areas where there is an accumulation of shallow organic materials (< 50 cm). The area is inundated by river water during rainy season when they receive nutrients to maintain forest biomass sustainability.
56. Ombrogenous peat is the true peat swamp (organic materials > 50 cm), where water and nutrients supplies are obtained only from the air such as from aerosol, debris and rainwater; it is situated far from river bodies and cover flow areas between water catchments.
57. Smoldering combustion is a type of combustion associated with a condition of limited oxygen (wind).
58. Biomass is the weight of organic matters of an organism per unit area on a particular time. Organic matter weight is generally stated in dry weight unit or sometimes in ash free dry weight. Therefore the unit for biomass is gr/m2 or kg/ha or tonnes/ha
59. Biomass can be categorized as above ground and below ground biomass.

I. INTRODUCTION

Figure 1. Palm oil seedlings in Cikidang (dok. Nanang S)

A. Background of Plantation Development in Indonesia

Cangkul, cangkul, cangkul yang dalam, menanam jagung di kebun kita, ... (Hoeing, hoeing, deep hoeing, planting corn on our field...)

When we were toddlers, we sang that song with happiness and hard claps. Do our plantations today still reflect the situation in that song? Perhaps some would say otherwise.

Kartodirdjo & Suryo (1991) remarks that "the history of plantation development in developing countries such as Indonesia cannot be separated from the history of colonialism, capitalism and modernization. In developing countries, plantations are generally the extension of western agricultural capitalism that was introduced through colonial economic system. During its early development, plantation arise as a novelty in economic system, that is as commercial agricultural economic with colonial character. Such system was basically European style of plantation system which is different than the garden system that has been used in developing countries during pre-colonial times".

The term "garden system" overlaps with several existing terms in Indonesia such as community plantation, agroforestry, and people-managed areas, etc. Even there exists a kind of customary management by indigenous or traditional people. Some of the local terms having similar meaning with garden system are *repong damar, simpunk, tembawang*, etc. Various terminologies also refer to the actors involve in garden system, including independent gardener, traditional community, indigenous community etc.

Garden system refers to plantation at household scale as an additional effort in agriculture especially related to cash crops. This is often found in small scale, does not required much investments, narrow use of land, labours come from household members, not market oriented and focus more to serve subsistence needs. This is differ from plantation system or currently known as large scale plantation system which is part of a commercial agricultural economic and capitalistic. This system is large scale, monoculture, require big investments, extensive use of land, intensive labours, detailed job descriptions, use of wage labourers, complex work relationship structure and market oriented (export commodities).

Table 1. Differences between Large Scale Plantation Company and Garden System

Item	Plantation System	Garden System
Actors	Investor only invest and does not become involve with direct planting	Involve with direct planting
Land Area	Large scale, often > 25 Ha	Most are less than 10 Ha
Orientation	Market and profit	Household needs
Capital	Financial (rich in investment)	Labour (rich in labour)
Developed Plants	Plants that are in market demand	Recognized plants and can fulfil household requirements

Source : Surambo, A. 2007. Sistem Kelola Rakyat Vs Sistem Kebun Besar. Bogor. Perkumpulan Sawit Watch

As discusses already, there are two type of plantation model, *i.e*., large scale and garden system. Both models were illustrated as black and white (opposites). Currently, both models are a continuum where at one extreme is the garden system and on the other extreme is the large plantation system. Therefore, apart from the two extreme models of plantation, there is a mix of both known as *petty cultivation* referring to plants that are planted for subsistence and trade purposes. This suggests that agricultural products are not only for subsistence purposes but could also be traded in markets.

Varieties of Local Agricultural System

Indonesia has many local agricultural systems that have adapted to the natural condition. If there is a change in nature, then the existing agricultural system will also change, meaning a new adapted agricultural system. These systems show the diversity of plants, land tenure, economical, cultural, technological and environmental motives that influence agriculture.

There are four agricultural systems known to exist, (Kartodirdjo & Suryo, 1991):

- **Shifting cultivation system –** a type of agricultural system which is done nomadically, by planting many short lived crops especially food crops. This agricultural system is marked by the ecological imitation nature of temporary agriculture, plant diversity and associated with low human population density.
- **Wet rice cultivation system –** a type of agricultural activity using wet rice as the main crop. Wet rice system is marked by one principal crop that is paddy rice. The system is also marked by complex agricultural irrigation, higher density compare to other systems and a model of centred power.
- **Garden system –** is a type of agricultural system that manages perennial plants or crops planted on permanent land. Usually the planted crop is hard woods. Some experts suggest that this system has been established in Indonesia since centuries ago, to be exact on 1200 BC. This garden system comprises of mix plants and garden dominated by specific species. Mix plant garden is often planted with hard woods and medicinal plants while garden dominated by specific plants often comprise of nutmeg-fuli, pepper, clove or coffee, rubber, etc. In several places, the gardens are developed on

dry fields and often planted with pepper, coffee or rubber. After planting is done, plants are left alone until fruiting season. This system is found outside Java, such as in Sumatra, Kalimantan and Sulawesi. For sure, this type of plantation system does not produce high yields like an intensive care garden.

- **Dry field system –** is a type of permanent food crop planting on dry field. One of the main crops is the dry field rice and mix crops (*palawija*).

Large Palm Oil Plantations

As discussed above, plantation can be divided into three types, *i.e*: commercial plantation that serves the market, subsistent plantation and petty cultivation. Palm oil is included as commercial plantation that serves the markets or large plantation. Initial identification of large plantations development suggests that plantation was initiated during the Dutch colonials when they introduced coffee to West Java (*Bumi Priangan*). This happened prior to liberal period (before 1870), of which during this period, there was a kind of "pilot project" of how to establish large plantation system to serve European markets.

It is still debatable where palm oil originated. Some believe it is originated from West Africa, while others believe from South America. Some experts believe that Africa and America used to be one, thus palm oil is found in these two places.

Palm oil entered Indonesia in 1848, where there were only four trees that were cultivated in Bogor Botanical Garden of which two were from Hortus Botanicus Amsterdam and the other two from Mauritus, hence palm oil in Indonesia probably originated from Africa although through different access. In order to develop the palm oil, it was cultivated in Banyumas (Java) and Palembang, and in 1875, palm oil plantation was established in Deli area (North Sumatra). Large scale palm oil plantation was established by Adrian Hallet in 1911 in Sungai Liput (Eastern Coast of Aceh) and Pulo Raja (Asahan). On the same year, K.L.T. Schadt also planted palm oil in Sungai Itam Ulu (Deli). By 1914, therefore the area of palm oil plantation totalled to 3,250 Ha.

Recently, Indonesia has a total area of 7.8 million Ha (see Table 2), which makes Indonesia as the largest palm oil producers in the world. The extent of the plantation itself was possible by converting forests and community forests into palm oil plantations. These were triggered by two things, *firstly*, the Indonesian government's policy to become the largest palm oil country in order to obtain various facilities such as licenses, low wage labours, etc. *Secondly,* high demand for biofuel especially those of palm oil's.

Table 2. Extent and Expansion Plan of Palm Oil Plantation in Indonesia

PROVINCE	2008	
	EXISTING (ha)	**EXPANSION (ha)**
BANGKA BELITUNG	138,367	-
BANTEN	17,375	-
BENGKULU	200,000	500,000
DAERAH ISTIMEWA YOGYAKARTA	-	-
DKI JAKARTA	-	-
GORONTALO	-	-
WEST PAPUA	-	-
JAMBI	694,310	1,000,000
WEST JAVA	11,881	20,000
WEST KALIMANTAN	434,459	5,054,600
SOUTH KALIMANTAN	391,671	500,000
CENTRAL KALIMANTAN	737,556	1,934,200
EAST KALIMANTAN	338,205	1,404,000
KEPULAUAN RIAU	14,936	-
LAMPUNG	164,786	500,000
M A L U K U	61,590	-
NORTH MALUKU	-	-
NANGGROE ACEH DARUSSALAM	283,283	930,000
WEST NUSA TENGGARA BARAT	-	-
EAST NUSA TENGGARA TIMUR	-	-

P A P U A	97,000	5,000,000
RIAU	1,800,000	3,024,600
SOUTHSULAWESI	72,133	500,000
CENTRALSULAWESI	81,307	500,000
SOUTHEAST SULAWESI	3,602	900,000
NORTHSULAWESI	-	-
WEST SULAWESI	310,281	
WEST SUMATERA	310,281	500,000
SOUTH SUMATERA	618,000	1,000,000
NORTH SUMATERA	1,044,230	1,159,800
TOTAL	7,825,253	24,427,200

Source: Various sources, Sawit Watch (2009)

Table 3. Palm oil development during Indonesian Government

Phase	Conditions	Influencing actors
Soekarno	This phase is marked by the Indonesian independence from Dutch and Japan. Social revolution was happening everywhere. One such practice was by evicting colonials. National assets owned by the colonials were taken over. One example was the sporadic occupation of plantations by Indonesian people. Even Bung Hatta stated that the current lands at the time were the results of "robbing" public lands. In relation to this statement, it was understandable why the land occupation occurred. One result of the Round Table Conference was the returned of foreign assets to the companies including the occupied lands. This situation was tragic, since Bung Hatta was	Large scale foreign companies, Soekarno's government whom some are militaries, national movement leaders

	the one who made the agreement but he was also the one to revoke. Another result from Round Table Conference was the returned of West Papua to Indonesia a year later. Due to the long term of such returned, Soekarno government has taken several monumental steps. Firstly, Soekarno's government hit hard on all debts to the Dutch colonials. Another phenomenal step was the nationalization of all Dutch companies. Due to lack of professionals at the time, militaries were involved in holding several plantation companies. The peak of Soekarno's popular policies was the land reform plan through the issued of Agrarian Law No 5 of 1960, where one object of land reform was large scale plantation. Before this land reform area can be conducted, unfortunately Soekarno's government experienced a fall. There were no significant steps during the course of land occupation on plantations, even some large plantations were neglected.	
Soeharto – reformation	During this phase, massive plantations were developed using a model of three principals, *i.e*, stability, growth and equivalent. One of the Soeharto's policies was the issue of foreign inverstments laws. One concept was partnership based, that is, the concept of People's Nucleus Estate (Perkebunan Inti Rakyat - PIR) which was part of green revolution, where in a large scale plantation there are nucleus and plasm. Nucleus had the responsibility of providing agricultural production facilities, market guarantee, and guarantor in the Bank; while plasm had the responsibility to supply land, labours and produced plantation results to the nucleus. PIR-	Department of Agriculture with its perangkat-nya, largescale plantation companies, NGOs, Farmers union, indigenous people, and labour

	plantation was firstly initiated through financial funding from World bank in 1997 on two locations, Alue Merah, Aceh and Tabenan, South Sumatra. This project was known as NES (Nucleus Estate Smallholder), and continued until NES V. For Kalimantan region, the PIR project was developed in two regions, *i.e.*, in Sanggau, West Kalimantan and Paser, East Kalimantan at the end of the 1980s. The PIR concept was rapidly developed and even integrated with other government's project, *i.e.*, transmigration through the issue of Presidential Instruction No 1 of 1986 on PIR – Transmigration. Several concepts on PIR are presented in Table 4. If we compare PIR with forced planting work, there are similarities and differences as tabulated in Table 5. During Soeharto's government, large scale palm oil plantations were developed though the conversion of forests. Currently, Indonesia has the largest palm oil plantation in the world covering a total of 7.8 million ha (Perkumpulan Sawit Watch, 2009). These large scale plantations caused severe impacts both for the environment and human being (social). Environmentally, the resulting impacts include forest fire, flood, landslides and water pollution due to wastes. Socially, development of these plantations produced conflicts between indigenous people and plantation companies as well as horizontal conflicts between labours and farmers/indigenous people. Based on data monitoring by Perkumpulan Sawit Watch there are as many as 523 conflicts cases across palm oil plantations in Indonesia. The monetary crisis in 1997 caused political crisis in Indonesia, which also resulted in the downfall of Soeharto government for 30 years	union

	and replaced by Reformation Order. One significant change was the application of decentralization instead of centralization in the governance. Under this governance, regional governments are given higher authorities. One of such is the issuing of licences to develop large scale plantation. As a result, there have been massive large scale plantations especially those of palm oil's. There were increasing impacts of large scale plantations during the new order. The SBY-JK government introduced what is called by agricultural revolution concept. This concept clearly supports the previous plantation system which clearly did not benefit the people. The most significant thing occurring during this phase was the occurrence of companies with land power conglomerates, see Table 6. Indonesia dependence in 1945 through revolution did not change the current plantation system where the it is adopted from the development of Liberal Phase during the Dutch colonials.	

B. Social and Environmental Impacts of Palm Oil Expansion

Introduction

Agrofuel – or is best known as biofuel – has been promoted as a solution to the problem of global warming due to its ability to continuously supply the global energy needs by producing carbon emissions that are lower than other fuels. Even European Union plans to establish 10 percent of all its transportation fuels from agrofuel by the year 2010.

Several organizations see the economic opportunities of agrofuels in proving employments and increasing welfare of developing countries, while others see it as a process of land and large scale resource privatization with the entrance of big companies. This could also trigger global warming since commodities producing agrofuels are mainly planted on converted forests and peatlands. Therefore, if accurately calculated, the total carbon released from forests and peat clearance for agrofuel will be higher than wastes of gases from transportation sector and factories using agrofuels.

As a result, palm oil plantations are accused as the main cause of forest clearance in Indonesia that has destroyed the lives of rare species including orangutan and tigers. The burning mechanism applied to clear and drain peatlands for the purpose for palm oil plantation, produces million tonnes of carbon dioxides (CO2) and placed Indonesia as the third major contributor of CO2 emissions in Indonesia.

Apart from the threatened Indonesian forests, the lives of about 60-90 millions Indonesian people are also threatened by the expansion of palm oil plantations. People have manage their lands for generations, planting food and commercial crops, harvesting medicinal plants and obtain building materials from plants. Some of the areas were protected communal forest. Palm oil plantations have transformed their lands into monoculture plantation and field results indicate that the transformation process is detrimental to the communities.

Impacts of Palm Oil Expansion

a. **Environmental Impacts**
Based on 2009 data from Sawit Watch, palm oil plantation expands annually with an average of 400 thousands ha. Out of this figure, forest clearance (primary and secondary) reaches 200 - 300 thousands annually. While for converted peat swamp areas could amounts to 100 – 150 thousands ha annually. Communal land managed by indigenous or local people could total to 50 – 100 thousand ha annually. As a result, annual floods occur, smokes during end of dry periods, scarcity of water, water and soil pollutions due to wastes and biodiversity decline which all point to global warming and climate change.

b. **Social Impacts**
The most vulnerable group due to palm oil expansion is the indigenous/traditional communities inhabiting or living adjacent to forests and peatlands. According to report by Sawit Watch there are at least 50 – 100 thousands ha of communal gardens and lands that are forced to be hauled by palm oil industries. Only few receive

little compensation in the form of plantings, while for the majority, no compensations are given. Furthermore, there are at least 20 indigenous communities that each year must face the law which tend to end up on criminal punishment since they show resistances for their management rights.

Furthermore, plasm farmers who are used as the slogan for palm oil plantation also receive negative impacts. Various forms of absorptions have been carried out by palm oil companies such as the return of land to the farmers often not on time/not as promised, the low quality and unsuitable in terms of size, amount of debts and high credit interests and not transparent. As well as the monopolization of procurement of seed, fertilizers, pesticides and other working equipments by the mother company or its partners, one sided determination of FFB price by the mother company, increase credit amounts and debt interests for replantation and the establishment of new form of partnership under one management would all inflict the farmers.

Other social impacts include seizement of labour rights in palm oil plantation. There is a minimum protection from work hazards, insufficient wages, and vulnerability to various forms of abusements and out of the total of 3 million labours working on palm oil plantation, about 65% are labours with no working contracts.

c. Cultural Impacts

The arrival of palm oil plantation has altered the social life system of local communities and destroys their cultures and indigenous values and knowledge leading to the loss of indigenous cultures. In some places, significant cultural places including ancestors' burial sites were destroyed and replaced with palm oil.

Tradition and rituals which have become parts of the local agricultural practices are also loss often due to the loss of sacred sites. As a result, local traditions and languages are also lost. Indigenous cultures are often not put in writings, thus if such culture dies, the whole important cultural components will also die along.

The expansions of unsustainable palm oil industries in Indonesia have caused the loss of forests and peatlands that are often buffer the areas from natural disasters and preventing global warming. Furthermore, many traditional communities loss their land and access to water and must live improper life. The once dependent communities now turn to be dependent on debts and must work hard to obtain access to education and fulfil their food requirements. In line with the destruction of Indonesian forests and wildlife, traditions and cultures are also destroyed due to this expansion process.

Palm oil companies and their funding organizations as well as Indonesia government must be responsible for the environmental degradation and local communities' conditions due to palm oil expansion in Indonesia. In addition, European countries and other international organizations should also be responsible in pressuring the consumption rate of agrofuel, especially consumption of palm oil. For the sake of social and environmental sustainability. For the one Earth that should be suitable for all human beings.

II. Development of Palm Oil Plantation Based on Greenhouse Gases

A. Global Warming Impacts of Increase Greenhouse Gases

Figure 2.1. Melting Ice in Antarctic (Photo: Jiwan, 2006)

Sun is the source of energy for Earth in the form of short wavelength (Tampang, 2009). Earth comprises of atmospheric layers, *i.e*., troposphere, stratosphere, mesosphere and thermosphere. Troposphere is the bottom layer (closest to Earth). Benny (2007) mentions that 35% of solar radiation does not reach the Earth because it is absorbed by thermosphere, mesosphere and stratosphere. Other radiations are emitted back to the atmosphere. About 65% of solar radiation that enters troposphere is absorbed by water vapour, debris and certain gases and approximately 37% are radiated directly to Earth. When solar energy (short wave energy) enters the Earth, sunlight is converted into heat that warms the Earth.

Some of the solar energy that is emitted back will be absorbed by atmospheric gases covering the Earth thus trapping the heat in the atmosphere. The trapped heat causes the Earth's temperature to keep increasing and subsequently resulted in what is known as "global warming". Wikipedia Online (2007) defines global warming as the increase of average atmosphere, sea and Earth temperatures due to heat accumulation by the atmosphere caused by gases that produce Greenhouse Effect. Greenhouse effect illustrates the real warming condition of plants within the real green house especially in cold climate areas. The warm effect occurs due to the presence of glass cover to trap solar radiation to keep the green house temperature warm.

Greenhouse effect (SLI, 2008) actually warms the Earth and makes it inhabitable for human and other forms of living things. Unfortunately, there is an over-accumulation of gases, which traps more heat from the sun causing global warming. Gases responsible for greenhouse effect are known as greenhouse gases.

Greenhouse Gases

Theoretically, global warming is related to the presence of solar radiation in the form of short wave that passes through the atmosphere and changes it to a long wave when it reaches the Earth's surface (SLI, 2008). When reaches the Earth, some of the waves are retransmitted to atmosphere. Some of the solar radiation in the form of long wave that is re-emitted by the Earth is trapped by the gases found within the atmosphere or what is known as the ***Greenhouse Gases*** **(GHG)**. The repeated trappings caused an accumulation of solar radiation on the Earth's atmosphere that in turn increases the Earth's temperature. This is known as ***Greenhouse Effect*** **(GHE)**, an analogue to the real condition within a green house.

B. Type of Greenhouse Gases

Under the United Nations Convention (SLI, 2008) on climate change (United Nation Framework Convention on Climate/ UNFCC), there are 6 types of gas classified as Greenhouse Gas, these are: Carbon dioxide (CO2), Dinitrioxide (N2O), Methane (CH4), Sulphur hexafluoride (SF6), Perfluorocarbon (PFCs) and Hydro fluorocarbon (HFCs). Sources of Greenhouse Gases based on activities are shown in Table 2.1.

Table 2.1. Source of Greenhouse Gases (SLI, 2008)

Greenhouse Gases	Source
Carbon dioxide CO2)	Fossil fuels combustion in energy, industry, transportation, agriculture sectors, deforestation
Methane (CH4)	Agriculture, land use change, biomass combustion, garbage end disposal
Nitroxide (N2O)	Fossil fuels combustions, industry, agriculture

Hydro fluorocarbon (HFCs)	Manufacture industry, freon industry, use of aerosol
Perfluorocarbon (PFCs)	Manufacture industry, freon industry, use of aerosol
Sulfur hexafluoride (SF6)	Electricity transmission, manufacture, freon industry, use of aerosol

The dominant sources of Greenhouse Gases that contribute the most to the increase emissions of greenhouse effect are CO_2, CH4 and N_2O (SLI, 2008), while HFCs, PFCs and SF6 only contribute about 1 % of the total greenhouse gas emissions although they have higher potentials to cause warming than CO_2, CH4 and N_2O.

Table 2.2. Index of global warming potentials of several greenhouse gases on CO_2 within 100 year (GWP, 1994) and their sources

Type of Gas	Index of Global Warming Potentials
CO_2	1
CH4	21
N_2O	310
HFCs	500
SF6	9,200

Source: KNLH, 1999

Actually GHE warms the Earth's temperature, making it inhabitable, where otherwise, Earth's temperature would be very cold. Unfortunately, various human activities have increased the GHE that are emitted to the atmosphere thus changing the GHG's compositions in the atmosphere that in turn increase trapped solar radiation which increases the Earth's temperature. This phenomenon is known as Global Warming which is marked by increased temperature which could be felt for the past two decades.

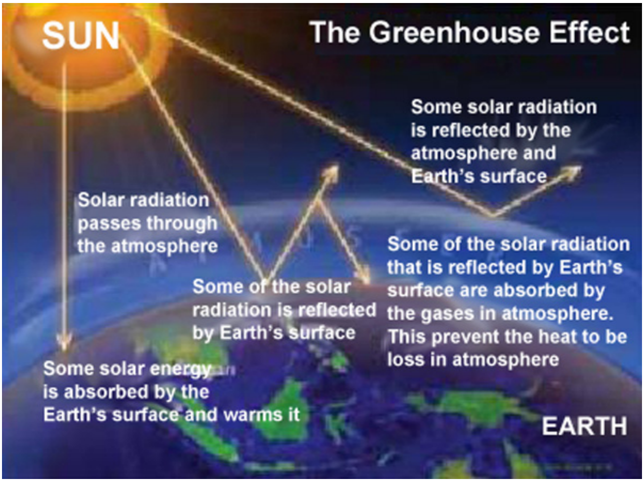

Figure 2.2. A simple diagram of greenhouse effect (SLI, 2008)

The IPCC (2007) mentions that the periods of 1995-2006 are considered as the 11 out of 12 years of the warmest Earth's temperature since 1850. The increased average temperature of Earth's surface in turn cause changes in the climatic components such as change in rainfall pattern and air pressure, increased vaporization or change of sea water temperature etc. As a whole this whole process is known as Climate Change as defined by the United Nation Framework Convention on Climate (UNFCC) as a change of climate which is attributable directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods' (IPCC, 2007). Wikipedia online (2007) states that apart from the six greenhouse gases causing greenhouse effect (based on Kyoto Protocol), water vapour is another recognize greenhouse gas (Tampang, 2008).

1. Water vapour

Water vapour is the most dominant greenhouse gas that occurs naturally from evaporation from sea, lake and river and is responsible for most of the greenhouse effect. Water vapour concentration fluctuates at regional scale and human activities have indirectly effect water vapour except at local scale. Increased temperature in atmosphere will increase water vapour within the troposphere with a more constant relative humidity. Increase water vapour will increase greenhouse effect; which will increase temperature and increase water vapour in the atmosphere. This process continues until it reaches equilibrium. The amount of water vapour in the atmosphere is also indirectly affected by the formation of clouds. As much as 25 % of the solar energy that reaches the Earth will be reflected by clouds or other particles in the atmosphere, 25% will be absorb by clouds, 45% is absorb by Earth's surface and the other 5% are re-emitted by Earth's surface (LAPAN, 2008). Clouds will re-emit infrared radiation to the surface thus increasing the temperature. According to Acehpedia Online, increase in water vapour in the atmosphere due to global warming will increase greenhouse effect.

2. Carbon dioxide

Carbon dioxide is the dominant greenhouse gas that contributes the most to global warming. According to Admin (2008), the natural concentration of CO2 is only 0.03 percent of the atmosphere and this gas is naturally used by plants during photosynthesis. Carbon dioxide is generated during the combustion of fossil fuels, solid wastes and wood to warm up buildings, generate vehicles and produce electricity. At the same time, the number of trees that are able to absorb carbon dioxide decreases due to increase logging and expansion of agricultural lands. Although the sea and other natural processes able to reduce the amount of carbon dioxide in the atmosphere, human activities in releasing carbon dioxide to the air are far more rapid than the ability of nature to reduce it. In 1750, there are about 281 carbon dioxide molecules per one million of air molecules (281 ppm). As of January 2007, carbon dioxide is at a concentration of 383 ppm (an increase by 36 percent). If currently there is an accurate prediction, then by 2100, the concentration of carbon dioxide will reach about 540 to 970 ppm. A higher estimation gives a figure of triple fold compared to pre-industrial revolution. Murdiyarso (2007) reports that based on 1997 emission data which comprised the previous 5 year data, the CO2 emissions in Indonesia amounted to 800 million tonnes where most of them originated from land use (change 600 million tonnes), placing Indonesia third as a country with the highest CO_2 emissions.

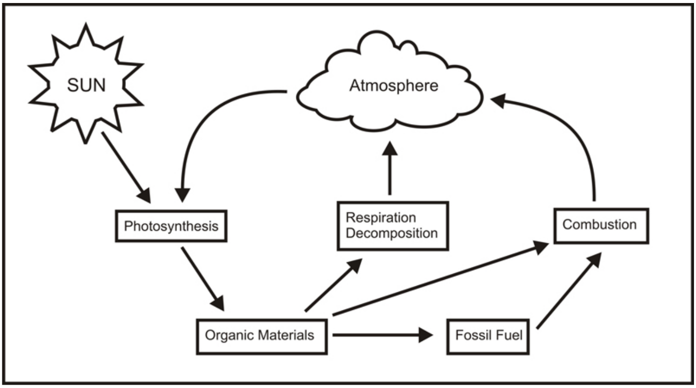

Figure 2.3. A Simple Carbon Cycle (Tampang, 2009)

3. Methane

Methane is the simplest hydrocarbon in the form of gas. The concentration of methane in the atmosphere is 1.7 ppm, where it is almost 2.5 higher that its concentration 300 years ago. Methane in the atmosphere is assumed to have a life span of 10 years. Methane is the principal component of natural gas and is an effective insulator that can trap about 20 times the heat of carbon dioxide. Methane is release during the production and transportation process of coal, natural gas and kerosene. Methane is also produced from decaying organic wastes in landfills, as well as from animal's wastes especially cows as a by product from digestion. The burning of one molecule of methane with oxygen will release one molecule of CO_2 and two molecules of water (H_2O) with the following chemical reaction:

$$CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O.$$

4. Nitrous oxide

According to Admin (2007), nitrous oxide is mainly produced during fossil fuel combustion and from agricultural land. The life span of NO_2 in the atmosphere is 150 years. The concentration of this gas has increased by 16% compare to its concentration prior to the industrial revolution. Nitrous oxide is a very strong heat insulator gas and can trap 300 times more heat than carbon dioxide.

5. Other gases

Other greenhouse gases are generated through various manufacturing process (Tampang, 2009). Fluoronation mix is generated through the aluminum melting. Hydrofluorocarbon (HCFC-22) is form during manufacture of various products. Some refrigerators in several developing countries are still using chlorofluorocarbon (CFC) as a cooling media that can prevent heatloss from the atmosphere as well as reducing ozone layer (layer that protect the Earth from ultraviolet radiation). HCFC has the capability of reducing or thinning ozone layers compare to CFC, since one chlorine atom of HCFC is replaced by hydrogen atom, reducing the weight of chlorine. The instability of HCFC causes its structure to disintegrate before reaching the ozone layer. CFC contributes about 15% of greenhouse effect (Pelangi, 2007). CFC on stratosphere will release chlorine when exposed to sunlight. Chlorine is then reacted with ozone to form chlorine monoxide (ClO) and oxygen, but ClO will disintegrate again releasing chlorine, followed by the process of ozone reduction.

The 2007 IPCC's report (Intergovernmental Panel on Climate Change) shows that in average the global human activities since 1750 has cause warming. Change in the abundant of greenhouse gases and aerosols due to sun radiation and Earth's surface affect the balance of climate energy system (Tampang, 2009). Radiative Forcing is a measurement to determine whether the global climate has become hot or cold, it can be concluded that global warming is mainly caused by human activities. The increase in amount and concentration of greenhouse gases are due to human activities such as fossil fuels combustion for the purpose of producing energy, transportation, industries, forest fires, land use changes for agriculture and animal husbandry (Tampang, 2009).

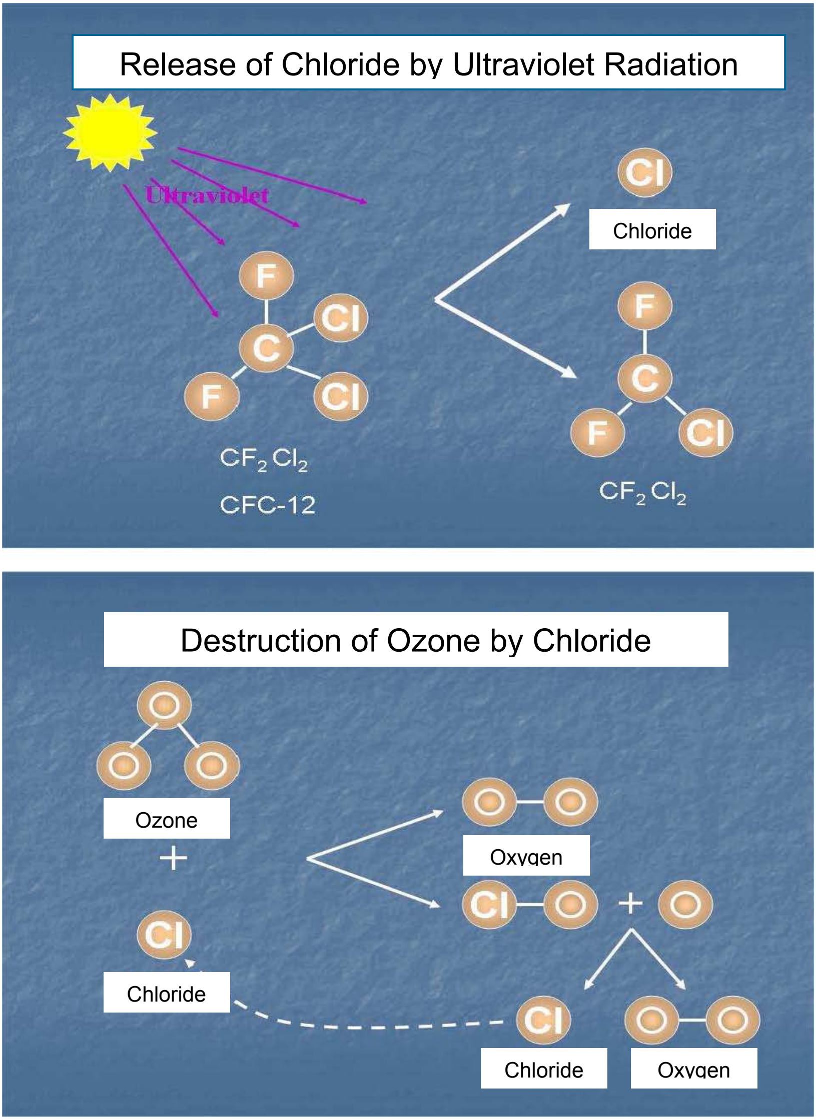

Figure 2.4. Ozone disintegration by chlorine (Murdiyarso, 2007)

C. Global Warming Impacts

Research results in Mauna Loa Observatorium, Hawaii (Saharjo,2008) shows that CO_2 abundant in the atmosphere has reached its highest on March 19 2004, having a figure of 379 ppm as reported by Russel Schnell (Deputy Director of NASA). The annual increase is estimated to be 3 ppm greater than the average annual increase of the previous decades, which was 1.8 ppm. Last year, the CO_2 abundant was 376 ppm, while during the pre-industrial era and prior to the use of fossil fuels, it was estimated to be only 280 ppm and IPCC estimates that by 2100 the figure will reach 650-970 ppm, hence IPCC predicts that there will be an increase of global temperature of 1.4-5.8°C between the years of 1990 and 2100. While Dr Eric Rignot and friends at NASA's Jet Propulsion Laboratory, Pasadena, California as stated in Science (October, 2003) said that Patagonia Ice field has lost its ice at the rate as the increase of sea level, *i.e*. 0.04 mm per year between 1975-2000 or equal to 9 % from the yearly total of global increase of sea level generated by mountain glacier according to IPCC Scientific Assessment (2001). Research by NASA as stated by Roger Peilke Sr, of Colorado State University shows that logging, urban development and plantation have contributed in increasing greenhouse gases. If land use pattern tend to be the same, it is estimated than within 50 years, the concentration of CO2 in the atmosphere will double. For example, if farmers transform their forestland into plantation, there would be less water to be evaporated that correlates with increase temperature of the area. However, according to Thomas Karl and Kevin Trenberth as reported by Science, industrial emissions are the dominant factor in changing climate pattern during the past 50 years. With this in mind, they have calculated that there will be an increase of global temperature of 1.7-4.9°C during the periods of 1990-2100.

One of the international research centre (Saharjo, 2008) as written in Nature, predicts that by 2050, approximately 18 – 37% of the species on Earth would become extinct as an impact of global warming. Similar statement also provided by Prof. Johanes Foufoulos of Michigan University (School of Natural Resources and Environment) whom remarks that each species required specific habitat and suitable environmental conditions to live in which was provided in the past years. Currently, human activities have caused fragmentations of ecosystem. While Kim Sorensen (1992) comments that the current carbon sequestration system of peat and other tropical rainforests will be impacted by climate change due to the disturbance of tree's abundance due of lack of associations. If global warming continues, then tropical rainforest will disappear due to increase dryness of the equator. Thus, based on geological record, it could be certain that Southeast Asia will become hotter and drier due to decreased biomass and high CO2 concentration in the atmosphere (Kim Sorensen, 1992).

Global warming is the result of accumulated greenhouse gases in the atmosphere that cause the rise of Earth's temperature. Based on IPCC Report *in* Kencana (2009) the average global air temperature increase was 0.6^{o}C between 1850 and 2000. Jakarta has experienced a temperature of 37^{o}C, where the normal temperature is 33^{o}C, while in Medan, North Sumatra, there was an increase of 0.17^{o}C/year during 1980-2002, and 0.87^{o}C/year in Denpasar (Kadarsah, 2008).

During this past century, Earth's temperature rises by 0.6 C. The main factor causing global warming is the increase of Greenhouse gases in the atmosphere. For the past decades, the CO_2 emissions has doubled from 1400 million tonnes/year to 2900 million tonnes/year, while CO_2 concentration in the atmosphere in 1998 was 360 ppmv with annual increment rate of 1.5 ppmv (Houghton et al., 2001). CO_2 emissions are 35 % higher in 2006 than 1990, a higher increase rate than expected (Candall, 2007). As a result, within the next 100 year, the average temperature on Earth is expected to up to 4.5ºC which will eventually have devastating impacts on human's lives (Murdiyarso, 2003).

Warming leads to many severe impacts often mediated by water (Stern, 2007):

1. Melting glaciers will increase flood risk during the wet season and strongly reduce dry-season water supplies to one-sixth of the world's population, predominantly in the Indian sub-continent, parts of China, and the Andes in South America.
2. Declining crop yields, especially in Africa, are likely to leave hundreds of millions without the ability to produce or purchase sufficient food. At mid to high latitudes, crop yields may increase with moderate temperature rise (2 – 3°C), but then decline with greater amounts of warming. At temperature of 4°C and above, the global food production may obtain severe impacts.
3. In higher latitudes, cold-related deaths will decrease. Climate change will increase worldwide deaths from malnutrition and heat stress. Vector-borne diseases such as malaria and dengue fever

could become more widespread if effective control measures are not taken.

4. Rising sea levels will result in tens to hundreds of millions more people flooded each year with a warming of 3 or 4°C. There will be serious risks and increasing pressures for coastal protection in Southeast Asia (Bangladesh and Vietnam), small islands in the Caribbean and the Pacific, and large coastal cities, such as Tokyo, New York, Cairo and London. It was estimated that in the middle of this century, about 200 millions people will loose their home permanently due to rise of sea level, severe flood and extreme drought.
5. Ecosystems will be particularly vulnerable to climate change, with one study estimating that around 15 – 40% of species face extinction with an increase of temperature by 2°C. Ocean acidification, a direct result of rising carbon dioxide levels, will have major effects on marine ecosystems, with possible adverse consequences on fish stocks.

Higher temperatures will increase the chance of triggering abrupt and large-scale changes (Stern, 2007):

1. Warming may induce sudden shifts in regional weather patterns like the El Nino- changes would have severe consequences for water availability and flooding in tropical regions and threaten the livelihoods of billions.
2. Many studies suggest that the Amazon forest is vulnerable to climate change, through the models that display significant dryness on this area. For example, one model found that an increase of 2-3°C will significantly destroy the Amazon rainforest which may not go back to its original state.
3. The melting ice will eventually threaten the land which is currently home to 1 of 20 people.

According to the Indonesian Law No 17 of 2004 (Tampang, 2009), the impacts of global warming include decreased food production, disturbance of water availability, spreading of plants pests and diseases as well as human diseases, rising of sea level, lost of small islands and extinction of biodiversity.

1. Weather and Climate

Temperature rising (Tampang, 2009) causes ecological change resulting in climate change (unpredictable climate). ***There will be prolong planting period in some areas. Temperature during cold season and night time will tend to increase. Hot season will become hotter and cold season will become more humid.***

Warmer areas tend to become more humid due to the increase water vapour from the sea. High humidity will increase rainfall, on average about 1 percent for every Fahrenheit. The global rainfall has risen about 1 percent within the last 100 years. The late rainy season 1 month later has impacted on the reduce production of rice in Java/Bali of 7-18% (Naylor et al, 2006 *in* Boer, 2007). The weather becomes unpredictable and more extreme. High rainfall increases the risk of flood while low rainfall results in droughts. The global effect is prolong dry periods (drought) and shorter rain periods as well as more frequent storms and floods, El-Niño and La Nina. The attachment of the Minister of Health Decree No. 289/Menkes/SK/III/2003 states that the impacts of El-Nino is global warming where prolong dry periods results in droughts and one of the main factor causing forest fires (Tampang, 2009). Indonesia has the risk of receiving impacts of El-Nino.

2. Drought

Increasing temperature will increase water evaporation from soil, thus causing some areas to become drier than previously known (Tampang, 2009). This drying condition would cause freshwater crisis. Drought also reduces food security due to lack of water on agricultural lands. As cited by daenk.co.cc (2008) based on clippings in mass media, Kompas and Gatra, that during 2005-2006, West Java has experienced reduction in rice production by 368,645 tonnes while in East Java (Brantas Watershed) during 2006-2007, the production declined to 220.519 tonnes and during the same period in Central Java, rice production fall to 350,436 tonnes.

During dry periods, wind will blow even harder and probably with different patterns. Storms obtain energy from water vapours thus will occur more frequently with greater power (Tampang, 2009). Droughts also increase vulnerability an area to forest fires. Hot temperature will dry forest biomass making them prone to fires, which triggers the increase of greenhouse gases which in turn cause global warming. These interrelationships of factors occur in a causal loop cycle.

3. Rising Sea Level

When the atmosphere warms up (Tampang, 2009), sea water surface will also warms up giving rise to its volume and rise of sea level. Warming will also melt the ice in the Arctic that cause water volume in the sea to rise, increasing sea levels. A scientist from the University of Trent, Canada as cited in Kompas dated 15 September 2008, remarks that melting of ice cap with a size of Manhattan city broke and fell off from Ellesmere Island in the North Arctic, which shows that the layer of ice is thinning thus not able to hold the whole ice blocks.

When sea level reaches river delta, the resulting flood due to tide will occur inland. Increase of sea level could drown small islands, especially in Indonesia which is an archipelagic country. Indonesia has 17.504 islands, and due to sea level rising, the total islands declines to 17.480. Sea water surface in Jakarta Bay has risen to 0.57 cm and land surface decreases by 0.8 cm/year (SLI, 2008). According to Masnerliyati Hilman (Deputy for the Minister of Environment Divison of Natural Resources Conservation and Environmental Degradation Control) due to global warming, Indonesia sea level rises by 0.8 cm annually which cause the drowning of small islands almost one meter within the next 15 years. Sea level rising can also increase pH of sea water that will inhibit the growth as well as kill marine biota and corals.

4. Agriculture

Climate change effects agriculture. The southern part of Canada (Tampang, 2009) may receive benefits from higher rainfall and prolong planting season, although there are areas that plants cannot grow due to increase temperature, such as in several parts of Africa with semi arid tropical agriculture.

5. Pests and Disease spread

Temperature rise increases the attacks of pests and disease on food crops. One example is pest known as *Rapa* that increases due to warmer cold season thus is conducive for such pest to thrive. This disease that never occurs in Scotland has spread from England. (Tampang, 2009). Global warming increases the temperature in Scotland, allowing *Rapa* to thrive under warmer cold weather. In addition, global warming has also caused the spread of diseases among humans. Based on data by WHO cited by Kadarsah (2008), global warming has increased malaria in several countries and the occurrence of new diseases. This may allow tropical epidemics, such as diseases caused by mosquitoes and other carriers, to be spread further to areas which are previously too cold for these carriers to thrive. Dengue and malaria mosquitoes are more dangerous in areas where their life cycle and incubation period becomes shorter. Shift in ecosystem could cause increase of waterborne and vector-borne diseases. Global warming is also responsible for the increase of diseases such as ISPA (due to long drought or forest fires), dengue fever (due to uncertain rainy periods). Prof Umat Fahmi Achmadi as cited in a national newspaper (Kompas) remarks that the increase of Earth's temperature pushed the heart to work harder to cool the body thus increasing asthma and skin cancer. Furthermore, Kadarsah (2008) reports that the people of Argentina, Chile and New Zealand are vulnerable to skin cancer, such as in Punta Arena Chile. The number of skin cancer patients increases 66 % during the years of 1994-2004 (Tampang, 2009).

6. Biodiversity Decline

According to Dr. David Bramwell (Director for Jardon Botanical Garden) in WAH (2009) "About half of the 400 thousands plant species in the world and 100 other unidentified species are threatened to be extinct if the Earth's temperature rises between 2-3^{o}C within the next 100 years". Moreover, Huang Hongwen (Director for Wuhan Botanical Garden) stated that currently, the rise of temperature of 0.6^{o}C has caused the migration of hundreds species of butterflies, birds, plants, bats to the north and south poles. Temperature rising has caused the lost of several species of flora and fauna. The aspens of Great Lakes have disappeared leading to the loss of forest biodiversity. The rise in temperature by 1-2^{o}C will cause coral bleaching while a temperature rise above 2^{o}C will kill an extensive area of corals (IPCC, 2007 *in* Kencana, 2009). Furthermore, it is stated that several lakes have shown signs of decrease number of fish with an increase of temperature close to 1^{o}C. Based on Kompas Online dated 23 December 2008 (Tampang, 2009), global warming also effects the sexual interaction of several animals where a rise in temperature produces more males than females. For examples as the case for reptiles, sex is determined by the temperature at which the eggs are incubated during embryonic development until they hatch. If the temperature is above average (pivotal temperature) the hatchlings are dominated by males. Similar conditions occur with fish such as that of genus Menidia and Apistogramma. These incidents will produce risks for the sustainability of such animals.

According to Prof. Eberhard Bruenig of Ramkamhaeng University, climate change in tropical countries during the next 50 years will include:

a. An increase of global temperature by 2 °C and 4 °C on local scale
b. Increase of sea surface temperature above 27°C that cause many hurricanes and storms
c. Increase of average humidity on water surface and forest land
d. Specifically on areas located on equator, there will be an increase of rain by 10 %

While the environmental changes on wet tropical areas due to climate change include:

a. Increase in respiration, transpiration and evaporation from plants, vegetation and soil surface
b. Quicker nutrients cycle and greater soil leaching
c. Increase attacks of pest and diseases
d. Increase harmful hazards
e. Increase frequency and threats of thunder on tree crowns
f. Increase risk of fire
g. Increase heat pressure and dryness on tree crowns

To reduce the impacts due to climate change, Kim Sorensen (1992) recommends to:

a. Lowering carbon emission by reducing the use of fossil fuels, changing current land use pattern and animal husbandry system
b. Recognize species responses on the changes of chemical components of atmosphere and climate change such as increased CO_2, reduced ozone, temperature increase and change in rainfall pattern
c. Use biospheric solution through tree plantation

7. Hazards

Indirect impacts of global warming will lead to hazards such as storms, landslide and flood due to extreme rain or tidal flood with the rising of water level. These hazards have taken the lost of so many lives, material and long term trauma (Tampang, 2009). Climate change has also caused disturbance on agricultural system including expansion of pests and diseases, in addition to drought that resulted in harvest failure which in turn increase the number of hungry people. This is worsened by the increase of type and extent of disease that attack human due to global warming. Bill McGuire, a geologist from the University College London stated that Earth quakes, volcano eruption, tsunami and landslide were all related to climate change (Kencana, 2009). Due to melting of ice, the Earth's crust located under the Earth try to find new equilibrium thus triggers the activity of magma and Earth quakes.

D. Global Warming Impacts on Human Rights

This sub-chapter becomes very important in relation to impacts of climate change on human rights in Indonesia. Indonesia has ratify several United Nations International Conventions related to human rights especially Civil and Political rights, Economical, Social and Cultural rights, Children's Rights, Racial Discrimination Abolishment Women Discrimination Abolishment and other ILO conventions. Despite the reservation and declaration of the convention when they were ratified, Indonesia is tied to the international legal rights to obey and carry out the various stated articles as outline in all of the conventions.

This section discusses the relationship between climate change and its impacts on human rights and how they are related as well as providing short illustration on the condition of human rights within the perspective of international human rights as reported by The United Nations High Commissioner for Human Rights on January 2009[i]. The following discussion is taken from the Report of the Office of the United Nations High Commissioner for Human Rights for dissemination purposes and public education on various impacts of climate change, relationship and impacts on the fulfilments of human rights.

Report of the Office of the United Nations High Commissioner for Human Rights outlines the relationship between climate change, environmental hazards and human rights. The report comments on the effects on specific rights: (1) the right to live, (2) The right to adequate food (3) the right to water, (4) the right to health, (5) the right to adequate housing, and (6) the right to self-determination; and effects on specific group especially (1) women, 92) children, and (3) indigenous people; displacement; conflicts and security risks and human rights implications of response measures.

1. Relationship between climate change, environmental hazards and human rights

The United Nations High Commissioner for Human Rights and Reports of the Office of the High Commissioner and the Secretary-General recognizes that climate change has a strong relation with environmental hazards and human rights. In their report, UNHRC reports that an increase in global average temperature of approximately 2° C will have a dominant and negative effects on ecosystems across the globe, on the good and services they provide. Currently, climate change is among the most important drivers of ecosystem changes, along with overexploitation of resources and pollution[ii]. Moreover, global warming will exacerbate the harmful effects of environmental pollution, including higher levels of ground-level ozone in urban areas. In view of such effects, which have implications for a wide range of human rights, it is relevant to discuss the relationship between human rights and the environment.

Principle 1 of the 1972 Declaration of the United Nations Conference on the Human Environment (the Stockholm Declaration) states that there is "a fundamental right to freedom, equality and adequate conditions of life, in an environment of a quality that permits a life of dignity and well-being". The Stockholm Declaration reflects a general recognition of the interdependence and interrelatedness of human rights and the environment[iii].

The Convention on the Rights of the Child provides that States parties shall take appropriate measures to combat disease and malnutrition "through the provision of adequate nutritious foods and clean drinking water, taking into consideration the dangers and risks of environmental pollution[iv]. Convention on Children Rights provides direction for a country to take appropriate steps to fight against diseases and malnutrition "through the provision of nutritious food and clean water by considering the hazards and threats of environmental pollution".

Equally, the Committee on Economic, Social and Cultural Rights (CESCR) has clarified that the right to adequate food requires the adoption of "appropriate economic, environmental and social policies" and that the right to health extends to its underlying determinants, including a healthy environment[v].

2. Impacts on certain rights

Global warming will potentially have implications for the full range of human rights especially of rights which seem to relate most directly to climate change-related impacts as identified by IPCC (*Intergovernmental Panel on Climate Change*).

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a. The rights to life

The right to life is explicitly protected under the International Covenant on Civil and Political Rights and the Convention on the Rights of the Child[vi]. Moreover, the Committee has clarified that the right to life imposes an obligation on States to take positive measures for its protection, including taking measures to reduce infant mortality, malnutrition and epidemics[vii]. The Convention on the Rights of the Child explicitly links the right to life to the obligation of States "to ensure to the maximum extent possible the survival and development of the child"[viii]. According to the Committee on the Rights of the Child, the right to survival and development must be implemented in a holistic manner, "through the enforcement of all the other provisions of the Convention, including rights to health, adequate nutrition, social security, an adequate standard of living, a healthy and safe environment …"[ix]

A number of observed and projected effects of climate change will pose direct and indirect threats to human lives. IPCC AR4 projects with high confidence an increase in people suffering from death, disease and injury from heat waves, floods, storms, fires and droughts. Equally, climate change will affect the right to life through an increase in hunger and malnutrition and related disorders impacting on child growth and development; cardio respiratory morbidity and mortality related to ground-level ozone.[x]

Climate change will exacerbate weather-related disasters which already have devastating effects on people and their enjoyment of the right to life, particularly in the developing world. For example, an estimated 262 million people were affected by climate disasters annually from 2000 to 2004, of whom over 98 per cent live in developing countries[xi]. Tropical storm hazards, affecting approximately 120 million people annually, killed an estimated 250,000 people from 1980 to 2000[xii].

Protection of the right to life, generally and in the context of climate change, is closely related to measures for the fulfilment of other rights, such as those related to food, water, health and housing. With regard to weather-related natural disasters, this close interconnectedness of rights is reflected in the operational guidelines on human rights and natural disasters by Inter-Agency Standing Committee (IASC)[xiii].

b. The right to adequate food

The right to food is explicitly mentioned under the International Covenant on Economic, Social and Cultural Rights, the Convention on the Rights of the Child and the Convention on the Rights of Persons with Disabilities and implied in general provisions on an adequate standard of living of the Convention on the Elimination of All Forms of Discrimination against Women and the International Convention on the Elimination of All Forms of Racial Discrimination. In addition to a right to adequate food, the International Covenant on Economic, Social and Cultural Rights also enshrines "the fundamental right of everyone to be free from hunger"[xiv]. Elements of the right to food include the availability of adequate food (including through the possibility of feeding oneself from natural resources) and accessible to all individuals under the jurisdiction of a State. Equally, States must ensure freedom from hunger and take necessary action to alleviate hunger, even in times of natural or other disasters[xv].

As a consequence of climate change, the potential for food production is projected initially to increase at mid to high latitudes with an increase in global average temperature in the range of 1-3° C. However, at lower latitudes crop productivity is projected to decrease, increasing the risk of hunger and food insecurity in the poorer regions of the word[xvi]. According to one estimate, an additional 600 million people will face malnutrition due to climate change [xvii] with a particularly negative effect on sub-Saharan Africa [xviii]. Poor people living in developing countries are particularly vulnerable given their disproportionate dependency on climate-sensitive resources for their food and livelihoods[xix]

The Special Rapporteur on the right to food has documented how extreme climate events are increasingly threatening livelihoods and food security.[xx] In responding to this threat, the realization of the right to adequate food requires that special attention be given to vulnerable and disadvantaged groups, including people living in disaster prone areas and indigenous peoples whose livelihood may be threatened.[xxi]

c. Rights to water

International Covenant on Economic, Social and Cultural Rights has defined the right to water as the right of everyone to sufficient, safe, acceptable, physically accessible and affordable water for personal and domestic uses, such as drinking, food preparation and personal and household hygiene[xxii]. The Convention on the Elimination of All Forms of Discrimination against Women and the Convention on the Rights of Persons with Disabilities explicitly refer to access to water services in provisions on an adequate standard of living, while the Convention on the Rights of the Child refers to the provision of "clean drinking water" as part of the measures States shall take to combat disease and Malnutrition[xxiii].

Loss of glaciers and reductions in snow cover are projected to increase and to negatively affect water availability for more than one-sixth of the world's population supplied by melt water from mountain ranges. Weather extremes, such as drought and flooding, will also impact on water supplies[xxiv]. Climate change will thus exacerbate existing stresses on water resources and compound the problem of access to safe drinking water, currently denied to an estimated 1.1 billion people globally and a major cause of morbidity and disease[xxv]. In this regard, climate change interacts with a range of other causes of water stress, such as population growth, environmental degradation, poor water management, poverty and inequality[xxvi].

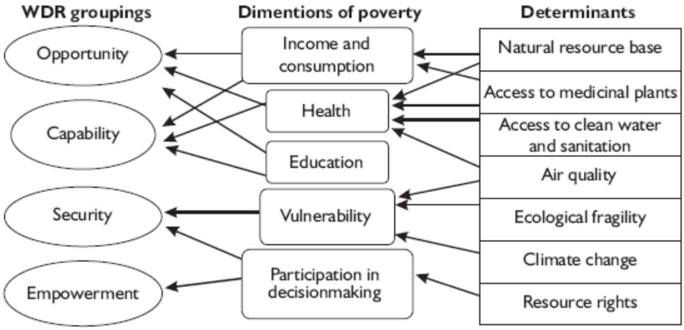
As various studies document, the negative effects of climate change on water supply and on the effective enjoyment of the right to water can be mitigated through the adoption of appropriate measures and policies[xxvii]

d. Rights to health

The right to the highest attainable standard of physical and mental health (the right to health) is most comprehensively addressed in article 12 of the International Covenant on
Economic, Social and Cultural Rights and referred to in five other core international human rights treaties[xxviii]. This right implies the enjoyment of, and equal access to, appropriate health care and, more broadly, to goods, services and conditions which enable a person to live a healthy life. Underlying determinants of health include adequate food and nutrition, housing, safe drinking water and adequate sanitation, and a healthy environment[xxix]. Other key elements are the availability, accessibility (both physically and economically), and quality of health and health-care facilities, goods and services [xxx].

Climate change is projected to affect the health status of millions of people, including through increases in malnutrition, increased diseases and injury due to extreme weather events, and an increased burden of diarrhoeal, cardio respiratory and infectious diseases[xxxi]. Global warming may also affect the spread of malaria and other vector borne diseases in some parts of the world [xxxii]. Overall, the negative health effects will disproportionately be felt in sub-Saharan Africa, South Asia and the Middle East. Poor health and malnutrition increases vulnerability and reduces the capacity of individuals and groups to adapt to climate change.

Dimensions of poverty and environment[xxxiii]



Climate change constitutes a severe additional stress to health systems worldwide, prompting the Special Rapporteur on the right to health to warn that a failure of the international community to confront the health threats posed by global warming will endanger the lives of millions of people[xxxiv]. Most at risk are those individuals and communities with a low adaptive capacity. Conversely, addressing poor health is one central aspect of reducing vulnerability to the effects of climate change.

Non-climate related factors, such as education, health care, public health initiatives, are critical in determining how global warming will affect the health of populations [xxxv]. Protecting the right to health in the face of climate change will require comprehensive measures, including mitigating the adverse impacts of global warming on underlying determinants of health and giving priority to protecting vulnerable individuals and communities.

e. The right to adequate housing

The right to adequate housing is enshrined in several core international human rights instruments and most comprehensively under the International Covenant on Economic, Social and Cultural Rights as an element of the right to an adequate standard of living.[xxxvi] The right to adequate housing has been defined as "the right to live somewhere in security, peace and dignity"[xxxvii]. Core elements of this right include security of tenure, protection against forced evictions,[xxxviii] availability of services, materials, facilities and infrastructure, affordability, habitability, accessibility, location and cultural adequacy [xxxix].

Observed and projected climate change will affect the right to adequate housing in several ways. Sea level rise and storm surges will have a direct impact on many coastal settlements [xl]. In the Arctic region and in low-lying island States such impacts have already led to the relocation of peoples and communities [xli]. Settlements in low-lying mega-deltas are also particularly at risk, as evidenced by the millions of people and homes affected by flooding in recent years.

The erosion of livelihoods, partly caused by climate change, is a main "push" factor for increasing rural to urban migration. Many will move to urban slums and informal settlements where they are often forced to build shelters in hazardous areas[xlii]. Already today, an estimated 1 billion people live in urban slums on fragile hillsides or flood-prone riverbanks and face acute vulnerability to extreme climate events [xliii].

Human rights guarantees in the context of climate change include: (a) adequate protection of housing from weather hazards (habitability of housing); (b) access to housing away from hazardous zones; (c) access to shelter and disaster preparedness in cases of displacement caused by extreme weather events; (d) protection of communities that are relocated away from hazardous zones, including protection against forced evictions without appropriate forms of legal or other protection, including adequate consultation with affected persons[xliv].

f. The right to self-determination

The right to self-determination is a fundamental principle of international law. Common article 1, paragraph 1, of the International Covenant on Economic, Social and Cultural Rights and the International Covenant on Civil and Political Rights establishes that "*all peoples have the right of self-determination*", by virtue of which "*they freely determine their political status and freely pursue their economic, social and cultural development*".[xlv] Important aspects of the right to self-determination include the right of a people not to be deprived of its own means of subsistence and the obligation of a State party to promote the realization of the right to self-determination, including for people living outside its territory.[xlvi] While the right to self-determination is a collective right held by peoples rather than individuals, its realization is an essential condition for the effective enjoyment of individual human rights.

Sea level rise and extreme weather events related to climate change are threatening the habitability and, in the longer term, the territorial existence of a number of low-lying island States. Equally, changes in the climate threaten to deprive indigenous peoples of their traditional territories and sources of livelihood. Either of these impacts would have implications for the right to self-determination

The inundation and disappearance of Small Island States would have implications for the right to self-determination, as well as for the full range of human rights for which individuals depend on the State for their protection. The disappearance of a State for climate change-related reasons would give rise to a range of legal questions, including concerning the status of people inhabiting such disappearing territories and the protection afforded to them under international law (discussed further below). While there is no clear precedence to follow, it is clear that insofar as climate change poses a threat to the right of peoples to self-determination, States have a duty to take positive action, individually and jointly, to address and avert this threat. Equally, States have an obligation to take action to avert climate change impacts which threaten the cultural and social identity of indigenous peoples.

3. Various effects on specific groups

The effects of climate change will be felt most acutely by those segments of the population who are already in vulnerable situations due to factors such as poverty, gender, age, minority status, and disability[xlvii]. Under international human rights law, States are legally bound to address such vulnerabilities in accordance with the principle of equality and non-discrimination.

Vulnerability and impact assessments in the context of climate change largely focus on impacts on economic sectors, such as health and water, rather than on the vulnerabilities of specific segments of the population[xlviii].

Submissions to this report and other studies indicate awareness of the need for more detailed assessments at the country level and point to some of the factors which affect individuals and communities.

1. Women

Women are especially exposed to climate change-related risks due to existing gender discrimination, inequality and inhibiting gender roles. It is established that women, particularly elderly women and girls, are affected more severely and are more at risk during all phases of weather-related disasters: risk preparedness, warning communication and response, social and economic impacts, recovery and reconstruction[xlix]. The death rate of women is markedly higher than that of men during natural disasters (often linked to reasons such as: women are more likely to be looking after children, to be wearing clothes which inhibit movement and are less likely to be able to swim). This is particularly the case in disaster-affected societies in which the socio-economic status of women is low[l]. Women are susceptible to gender-based violence during natural disasters and during migration, and girls are more likely to drop out of school when households come under additional stress. Rural women are particularly affected by effects on agriculture and deteriorating living conditions in rural areas. Vulnerability is exacerbated by factors such as unequal rights to property, exclusion from decision-making and difficulties in accessing information and financial services[li].

Studies document how crucial for successful climate change adaptation the knowledge and capacities of women are. For example, there are numerous examples of how measures to empower women and to address discriminatory practices have increased the capacity of communities to cope with extreme weather events[lii].

International human rights standards and principles underline the need to adequately assess and address the gender-differentiated impacts of climate change. In the context of negotiations on the United Nations Framework Convention on Climate Change, States have highlighted gender-specific vulnerability assessments as important elements in determining adaptation options[liii].

2. Children

Studies show that climate change will exacerbate existing health risks and undermine support structures that protect children from harm[liv]. Overall, the health burden of climate change will primarily be borne by children in the developing world[lv]. For example, extreme weather events and increased water stress already constitute leading causes of malnutrition and infant and child mortality and morbidity. Likewise, increased stress on livelihoods will make it more difficult for children to attend school. Girls will be particularly affected as traditional household chores, such as collecting firewood and water, require more time and energy when supplies are scarce. Moreover, like women, children have a higher mortality rate as a result of weather-related disasters.

Today's children and young persons will shape the world of tomorrow, children are central actors in promoting behaviour change required to mitigate the effects of global warming. Children's knowledge and awareness of climate change also influence wider households and community actions[lvi]. Education on environmental matters among children is crucial and various initiatives at national and international levels seek to engage children and young people as actors in the climate change agenda[lvii].

The Convention on the Rights of the Child, which enjoys near universal ratification, obliges States to take action to ensure the realization of all rights in the Convention for all children in their jurisdiction, including measures to safeguard children's right to life, survival and development through, inter alia, addressing problems of environmental pollution and degradation. Importantly, children must be recognized as active participants and stewards of natural resources in the promotion and protection of a safe and healthy environment[lviii].

3. Indigenous people

Climate change, together with pollution and environmental degradation, poses a serious threat to indigenous peoples, who often live in marginal lands and fragile ecosystems which are particularly sensitive to alterations in the physical environment[lix]. Climate change-related impacts have already led to the relocation of Inuit communities in Polar Regions and affected their traditional livelihoods. Indigenous peoples inhabiting low-lying island States face similar pressures, threatening their cultural identity which is closely linked to their traditional lands and livelihoods[lx].

Indigenous peoples have been voicing their concern about the impacts of climate change on their collective human rights and their rights as distinct peoples [lxi]. In particular, indigenous peoples have stressed the importance of giving them a voice in policymaking on climate change at both national and international levels and of taking into account and building upon their traditional knowledge[lxii]. As a study cited by the IPCC in its Fourth Assessment Report observes, “Incorporating indigenous knowledge into climate change policies can lead to the development of effective adaptation strategies that are cost-effective, participatory and sustainable”[lxiii]

The United Nations Declaration on the Rights of Indigenous Peoples sets out several rights and principles of relevance to threats posed by climate change.[lxiv] Core international human rights treaties also provide for protection of indigenous peoples, in particular with regard to the right to self-determination and rights related to culture.[lxv] The rights of indigenous peoples are also enshrined in ILO Convention No. 169 (1989) concerning Indigenous and Tribal Peoples in Independent Countries.

Indigenous peoples have brought several cases before national courts and regional and international human rights bodies claiming violations of human rights related to environmental issues. In 2005, a group of Inuit in the Canadian and Alaskan Arctic presented a case before the Inter-American Commission on Human Rights seeking compensation for alleged violations of their human rights resulting from climate change caused by greenhouse gas emissions from the United States of America.[lxvi] While the Inter-American Commission deemed the case inadmissible, it drew international attention to the threats posed by climate change to indigenous peoples.

D. Displacement

The First Assessment Report of the IPCC (1990) noted that the greatest single impact of climate change might be on human migration. The report estimated that by 2050, 150 million people could be displaced by climate change-related phenomena, such as desertification, increasing water scarcity,

and floods and storms[lxvii]. It is estimated that climate change-related displacement will primarily occur within countries and that it will affect primarily poorer regions and countries [lxviii].
There are four main climate change-related displacement scenarios [lxix] where displacement is caused by: (1) Weather-related disasters, such as hurricanes and flooding; (2) Gradual environmental deterioration and slow onset disasters, such as desertification, sinking of coastal zones and possible total submersion of low-lying island States; (3) Increased disaster risks resulting in relocation of people from high-risk zones; and (4) Social upheaval and violence attributable to climate change-related factors.

Persons affected by displacement within national borders are entitled to the full range of human rights guarantees by a given State,[lxx] including protection against arbitrary or forced displacement and rights related to housing and property restitution for displaced persons.[lxxi] To the extent that movement has been forced, persons would also qualify for increased assistance and protection as a vulnerable group in accordance with the Guiding Principles on Internal Displacement. However, with regard to slow-onset disasters and environmental degradation, it remains challenging to distinguish between voluntary and forced population movements.

Persons moving voluntarily or forcibly across an international border due to environmental factors would be entitled to general human rights guarantees in a receiving State, but would often not have a right of entry to that State. Persons forcibly displaced across borders for environmental reasons have been referred to as "climate refugees" or "environmental refugees". The Office of the United Nations High Commissioner for Refugees, the International Organization for Migration and other humanitarian organizations have advised that these terms have no legal basis in international refugee law and should be avoided in order not to undermine the international legal regime for the protection of refugees[lxxii].

The Representative of the Secretary-General on human rights of internally displaced persons has suggested that a person who cannot be reasonably expected to return (e.g. if assistance and protection provided by the country of origin is far below international standards) should be considered a victim of forced displacement and be granted at least a temporary stay.[lxxiii]

One possible scenario of forcible displacement across national borders is the eventual total submergence of small island States[lxxiv]. Two working papers of the Sub-Commission on the Promotion and Protection of Human Rights point to some of the human rights issues such situations would raise, such as the rights of affected populations vis-à-vis receiving States and possible entitlement to live in community[lxxv]. Human rights law does not provide clear answers as to the status of populations who have been displaced from sinking island States. Arguably, dealing with such possible disasters and protecting the human rights of the people affected will first and foremost require adequate long-term political solutions, rather than new legal instruments[lxxvi].

E. Conflicts and Security Risks

Recent reports and studies identify climate change as a key challenge to global peace and stability[lxxvii] This was also recognized by the Norwegian Nobel Committee when, in 2007, it awarded the Nobel Peace Prize jointly to the IPCC and Al Gore for raising awareness of man-made climate change[lxxviii] Equally, in 2007, the Security Council held a day-long debate on the impact of climate change on peace and security.

According to one study, the effects of climate change interacting with economic, social and political problems will create a high risk of violent conflict in 46 countries - home to 2.7 billion people[lxxix] These countries, mainly in sub-Saharan Africa, Asia and Latin America, are also the countries which are particularly exposed to projected negative impacts of climate change.

Climate change-related conflicts could be one driver of forced displacement. In such cases, in addition to the general human rights protection framework, other international standards would be applicable, including the Guiding Principles on Internal Displacement, international humanitarian law, international refugee law and subsidiary and temporary protection regimes for persons fleeing from armed conflict. Violent conflict, irrespective of its causes, has direct implications for the protection and enjoyment of human rights. It should be noted, however, that knowledge remains limited as to the causal linkages between environmental factors and conflict and there is little empirical evidence to substantiate the projected impacts of environmental factors on armed conflict[lxxx]

F. Human rights implications of response measures

The United Nations Framework Convention on Climate Change and its Kyoto Protocol commit States parties to minimize adverse economic, social and environmental impacts resulting from the implementation of measures taken to mitigate or adapt to climate change impacts ("response measures")[lxxxi]. With regard to measures to reduce the concentration of greenhouse gases in the atmosphere (mitigation), agro-fuel production is one example of how mitigation measures may have adverse secondary effects on human rights, especially the right to food[lxxxii].

Whereas agro-fuel production could bring positive benefits for climate change and for farmers in developing countries, agro-fuels have also contributed to increasing the price of food commodities "because of the competition between food, feed and fuel for scarce arable land"[lxxxiii]. CESCR has urged States to implement strategies to combat global climate change that do not negatively affect the right to adequate food and freedom from hunger, but rather promote sustainable agriculture, as required by article 2 of the United Nations Framework Convention on Climate Change. Apart from the impact on the right to food, concerns have also been raised that demand for biofuels could encroach on the rights of indigenous peoples to their traditional lands and culture[lxxxiv].

Concerns have also been raised about possible adverse effects of reduced emissions from deforestation and degradation (REDD) programmes. These programmes provide compensation for retaining forest cover and could potentially benefit indigenous peoples who depend on those forest resources. However, indigenous communities fear expropriation of their lands and displacement and have concerns about the current framework for REDD. The Permanent Forum on Indigenous Issues stated that new proposals for reduced emissions from deforestation "must address the need for global and national policy reforms, respecting rights to land, territories and resources, and the rights of self-determination and the free, prior and informed consent of the indigenous peoples concerned[lxxxv]

III. IMPLICATION OF GLOBAL WARMING ON INDONESIA

At global and national scales, global warming and climate change are believed to have caused the increase of temperature that trigger various negative impacts on human and environment (SLI, 2008). Theoretically, global warming and climate change will increase the average Earth's temperature, change rainfall pattern and increasing sea level. These changes are potential to cause health problems and environmental alterations such as flood and drought which seems to expand these recent years, declining productive lands area, extinction of various flora and fauna as well as habitat degradation, disturbance of coastal areas including small island and development of various diseases harmful to human health.

A. Increased Air Temperature

IPCC (2007) classified Indonesia in group with other countries having increased temperature between 0,2ºC to less than 1 º C for the periods of 1970-2004. At global level, since the end of the 19th century to early 21st century, the average increase of Earth's temperature is 0,76 º C.

B. Flood, Drought and Decreasing Agricultural Products

Global warming is very likely to cause drought and extreme rainfall which eventually will result in a much bigger climate hazard (IPCC, 2007; KNLH, 2007). Related to this, the United Nations Office for the Coordination of Humanitarian Affairs has identified that Indonesia is one of the countries that are vulnerable to climate-related hazards (SLI, 2008). One of the main influence on Indonesian climate is the "El-Nino Southern Oscillation" which every certain period of years triggered extreme climate incidents. El-Nino is related to the various changes in sea current in the Pacific which cause the sea water to become extremely warm (SLI, 2008). El-Nino is often associated with long drought periods, whereas during La Nina, sea current becomes very cold. There is a potentially high rainfall during la Nina resulting flood in many areas.

In association with climate-related disasters (SLI, 2008), within the periods of 2003-2005 alone, there were about 1,429 disaster incidents in Indonesia, where approximately 53.4% are hydro-meteorological disasters. Out of this, flood occurs most often (34%) followed by landslides (16%). Change of rainfall pattern due to climate variability (SLI, 2008) or season often followed by temperature increase, which results in water scarcity that could caused other inflicting side impacts.

C. Rising Sea Level and Threats on Small Islands

IPCC (2007) reports that the average sea level has rise to 1.8 mm/year in association with global warming. Sea level since 1961 was in average within the range of 1.3 and 2.3 mm/year and increase to 3.1 mm/year with range of 2.4 and 3.8 mm/year since 1993. At global scale, this is related to glacier melting and ice melting in Antarctic.

Table 3.1. Increase of sea level on various monitoring station (SLI, 2008)

Location of Station	Rising sea water surface (mm/year)	Source
Cilacap	1.30	Hadikusuma, 1993
Belawan	7.83	ITB, 1990
Jakarta	4.38	ITB, 1990
	7.00	Based on 1984-2006 data
Semarang	9.37	ITB, 1990
	5.00	Based on 1984-2006 data
Surabaya	1.00	Based on 1984-2006 data
Sumatra	5.47	ITB, 1990
Panjang, Lampung	4.15	P3O-LIPI, 1991

Source: MoE, 2007

Based on monitoring in certain areas, Indonesia sea water level experiences a rise between 1 - 9.7 mm/year. Unfortunately this has increased the potential lost of small islands. Study of climate change and sea level rise in Indonesia and their impacts on the lost of small islands have not been specifically carried out. However, the actual lost of several small islands based on data by Ministry of Marine and Fisheries (Table 3.2) indicates that this condition is currently occurring and further lost should be anticipated. Table 3.2 shows that Indonesia has lost 24 small islands between 2005 and 2007.

Table 3.2. Number of lost islands in several provinces in Indonesia

No.	Province	Lost islands
1	Nanggroe Aceh Darussalam	3
2	North Sumatra	3
3	Islands of Riau	5

4	West Sumatra	2
5	South Sulawesi	1
6	Jakarta	7
7	Papua	3
	Total	24

Global warming and climate change are also potential causes of sea temperature rising that can cause disturbance on sea and costal ecosystems. Burke et al., (2002) in KNLH (2007) remarks that increase in sea water temperature especially during the 1997 El-Nino, has caused serious damages on the coral ecosystems, which was the main reason for destruction of about 18% of coral ecosystem in Southeast Asia. In Indonesia, coral bleaching occurs in many places including Eastern part of Sumatra, Java, Bali and Lombok. In Thousand Islands, almost all corals (90-95%) on depth of 25 m were identified as having bleached (KNLH, 2007).

D. Biodiversity

1.Flora

Indonesia is a mega-diversity country with high biodiversity comprising of ecosystem, species and genetic diversities. As the biggest archipelago in the world with approximately 18,000 islands and its condition and geographical nature, Indonesia is second after Brazil as country with the highest biodiversity (SLI, 2008).

About 12% of world's mammals (515 species) can be found in Indonesia, 16% reptiles (781 species) and 35 species of primates have placed Indonesia fourth in the world. Furthermore 17% of the total bird species (1,592 species) and 270 amphibians placed Indonesia at fifth and sixth positions (Milttermier et al, 1997).

Table 3.3. Rank of countries with the highest biodiversity and endemism in the world

No	Country	Biodiversity value	Endemism Value	Total Value
1	Brazil	30	18	48
2	Indonesia	18	22	40

3	Colombia	26	10	36
4	Australia	5	16	21
5	Mexico	8	7	15
6	Madagascar	2	12	14
7	Peru	9	3	12
8	China	7	2	9
9	Filipina	0	8	8
10	India	4	4	8

Source: Mittermeier et al., 1997, in IBSAP, 2003

Indonesia ranks fifth in the world in terms of plants diversity, comprising of more than 38,000 species where 55% are endemic and 10% (about 27,500) are flowering species. Indonesia palm diversity ranks first with 477 species. More than 350 species of Dipterocarp family have significant economic value in Indonesia, where 155 species are endemic to Kalimantan (Newman, 1999).

Uncontrolled increased of natural resources utilization will threaten the existence of various ecosystems and related life systems. Habitat alteration due to shifting cultivation, forest conversion to agriculture, settlements, tourism, climate change, introduction of exotic species in an ecosystem could trigger the lost of the ecosystem and extinction of endemic species which at the end will result in genetic lost of that species (SLI, 2008).

Forest clearance into palm oil plantation, has contributed to the destruction of forest areas. Throughout 2003, the total area of palm oil plantation was 5.25 million ha and in 2005 was 5.59 million ha. It was estimated that expansion of palm oil plantation would continue up to 2020 to about 13.8 million ha. Conversion of natural forest into palm oil plantation is a serious threat for biodiversity, especially since conversion was mostly done on lowland tropical forest which is the ecosystem with the highest diversity. **Therefore, development of palm oil should not be conducted on natural forest but rather on abandoned lands** (SLI, 2008).

2. Fauna

Extinction of flora and fauna can be caused by natural factor such as evolution process and increased human activities where during the past decades they are assumed to cause species extinction at the rate of 40 to 400 times the natural extinction rate (SLI, 2008).

Human activities such as hunting, illegal wildlife trades, habitat destruction, over exploitation, illegal logging, forest encroachment and introduction of exotic species have placed Indonesia as a country with a long list of threatened species (SLI, 2008). The list includes 140 species of birds, 63 mammals and 21 reptiles. As many as 382 species have been put under protection and there is a possibility that the number will grow in relation to the higher threats faced by various species in Indonesia.

Table 3.4. Protected fauna and flora

FAUNA		
No	**Class/family**	**Number of species**
1	Mammal	70
2	Aves (birds)	193
3	Reptiles	31
4	Insects	20
5	Pisces	7
6	Anthozoa	1
7	Bivalva	14
FLORA		
1	Palmae	14
2	Orchidaceae (orchids)	29
3	Dipterocarpaceae	13
4	Nephentes	1
5	Rafflesia	1

Source: Departemen Kehutanan, 2007

Recently, there are about 58 rare plant species (wood, rattan, orchid, etc) where some are as medicinal plants (Table 3.5).

Table 3.5. Several rare medicinal plants in Java Island

No	Scientific Name	Family	Local Name	Status
1.	*Alstonia scholaris (L) R.*	Apocynaceae	Lame, pulai, pule	Rare

	Br.			
2.	*Alyxia reinwardtii Bl.*	Apocynaceae	Pulasari, cukangkang	Rare
3.	*Arcangelisia Flava (L) Merr.*	Menispermaceae	Ki koneng	Vulnerable
4.	*Cibotium barometz (L) J.Sm.*	Dikcsoniaceae	Paku simpai	Rare
5.	*Cinnamomum sintoc Bl.*	Lauraceae	Sintoc, kiteja, tejo	Extinct
6.	*Curcuma petolata Roxb.*	Zingiberaceae	Koneng putri, temu badur	Threatened
7.	*Euchresta horsfieldii (Lesch.) Benn.*	Fabaceae	Pranajiwo, ki jiwo	Rare
8.	*Kadsura scandens (BL) BL*	Schisandraceae	Wera areuy, ki lembur	Rare
9.	*Merremia mammosa (Lour.) Hallier f.*	Convolvulaceae	Widara upas, telo ndurak	Rare
10.	*Oroxylum indicum (L) Vent*	Bignoniaceae	Pongporang, gompong, pedang-pedangan	Rare
11.	*Parameria laevigata (Juss.) Moldenke*	Apocynaceae	Kayu rapet, congkangkang	Rare
12.	*Parkia roxburghii G.Don*	Fabaceae	Kedawung, peundeuy	Rare
13.	*Pimpinella pruatjan Molkenb.*	Apiaceae	Antanan gunung	Threatened
14.	*Rafflesia padma Bl.*	Rafflesiaceae	Kembang padma	Vulnerable
15.	*Rafflesia zollingeriana*	Rafflesiaceae	Padma	Threatened

	Koord.			
16.	*Scutella javanica Jungh.*	Lamiaceae	Perlutan, hamperu lemah	Extinct
17.	*Strychnos ignatii Berg.*	Loganiaceae	Cetek	Rare
18.	*Symlocos odoratissima (BL) Choisy*	Symplocaceae	Ki sariawan	Rare

Source : Rifai, et al., (1992): Zuhud, 2001

E. Diseases

Other than influencing the decrease of agricultural products, climate change also cause the development of various diseases that disturbed plants (SLI, 2008). Within the last 5 years for example, the Gemini disease has attacked the production centre of chilli and potatoes in Java (Bogor, Cianjur, Brebes, Wonosobo, Magelang, Klaten, Boyolali, Kulonprogo, Blitar and Tulungagung). This viral disease is carried by *Bemisia tabaci* Gennadius**.**

Climate change (SLI, 2008) is believed by various groups to cause the development of diseases, such as increase incidents of dengue fever. There is an indication that dengue fever is indicated to significantly increase during the past few years (Figure 3.1).

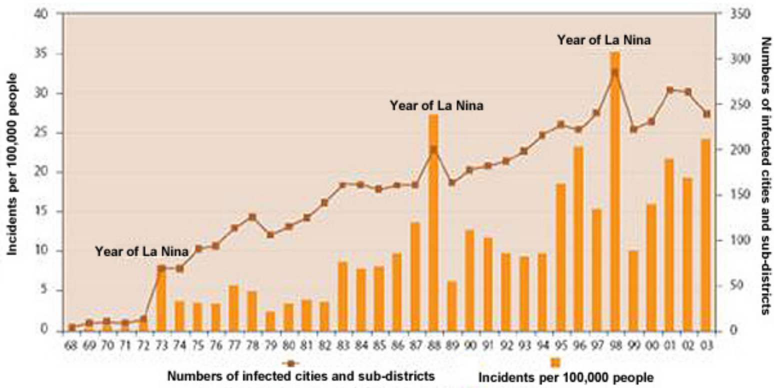


Figure 3.1. Dengue fever incidents and distance of infected cities and sub-districts, 1968- 2003 (SLI, 2008)

IV. REASONS FOR GLOBAL WARMING IN INDONESIA

Figure 4.1. Forest Clearance for Plantation (dok. SW)

A. Forest and Land Fires

The first forest fire incident in Indonesia (Saharjo, 2008) was found in East Kalimantan (Goldammer and Seibert, 1990). ^{14}C-data from charcoaled soil found along the East-West transect between Sangkulirang in Makassar Straits and about 75 km inland suggests that forest fires occurred between 17,510 and 350 BP. The fire was probably of natural cause during drier periods than today, although at such time human also burn forest for more than 10,000 years to facilitate hunting and clearance of agricultural plots (Saharjo, 2008). Written historical records as well as verbal information from people who conduct forest clearance showed that forest fire is not a novelty.

Forest Fire in Indonesia

The first documented report of impact of extreme drought in East Kalimantan was provided by Bock(Goldammer, 1996), a Denmark zoologist who travel the lowland forest area of east Kalimantan in 1878. he reported the presence of drought and hunger during his visit (Goldammer, 1996). He recorded that one third of all the trees found in the forest around Kaman muara within the intern Mahakam died of drought. Grabobsky, in 1890 (Saharjo, 2008) reported two fires within two mountain range, on Batu Puno in the centre part of South Kalimantan, which occur several years before his visits on 1881-1884, where the two mountain ranges died of fire. During 1914-1915, forest fire is again reported in Borneo. A recorded publication found in Sabah showed that 80.000 ha of tropical forest and peatlands were burned following drought. On wet tropical forest, a long drought will drastically change the nature of fuels and their ability to burn. Monthly rainfall of less than 100 mm and a period without rain for at least two weeks will cause progressive heat on the heat through the increased drying.

Table 4.1 Big fire incidents in Indonesia

No.	Year	Note/Total area (ha)
1	15.510 BC-1650 AD	First forest fire in East Kalimantan
2	1877	First recorded fire
3	1915	80.000
4	1982/1983	3.600.000
5	1987	66.000
6	1991	500.000
7	1994	5.110.000
8	1997/1998	10.000.000
9	2006	6-8.0000

1. Forest fires in 1982/1983

A big forest fire in Indonesia in the 20th century occurred in 1982/1983 especially in east Kalimantan where 3.6 million ha of forest and land were burned (Saharjo, 2008). A study by ITTO-GTZ concludes that the reason for forest fire is the change of vegetation structure due to logging which was started in 1970s, where millions ha of forestland were divided into logging concession areas. This has resulted in the log booming in Sumatra and Kalimantan which change the landscape of the islands for more than two decades.

As a result, there are many unused logs on the forest that cause the accumulation of fuels thus vulnerable to fire (Saharjo, 2008). Government and logging concessions' failures in protecting logging areas and closing of old logging roads cause invasion by encroacher into the forest and increase the complexity of the problems since they use forest for land clearance.

2. Forest fires in 1987

The impact of 1987 forest fire is not as great as the 1982/1983 fire (Saharjo, 2008). However, many parts of Indonesia experienced such impacts such as Kalimantan, Sulawesi, Sumatra, Bali, Nusa Tenggara and Timor. Based on government data (MoF), the total burned area is 66,000 ha. Source of fire was thought to be shifting cultivators as well as flaming coal which triggered fire on conservation areas particularly on Bukit Soeharto area. However, this statement was denied by an environmental group who instead blame logging concession company for causing the fire (Saharjo, 2008).

3. Forest fires in 1991

The 1991 forest fire occurred in Sumatra, Kalimantan, Sulawesi, Java, Bali and Nusa Tenggara (Saharjo, 2008) with a total burned areas of 500.000 ha based on government official data. The resulting smoke have caused the malfunction of transportation modes and also resulted in many accidents. Due to this, many domestic flights were postponed due to short visibility causing a loss of flight operation cost of Rp 6.5 million. According to the Minister of Forestry at the time, the assumed loss due to the fire was Rp.175 trillion. The cause of fire was land use change by Industrial Forest Plantation companies and shifting cultivators.

4. Forest fires in 1994

The 1994 forest fire (Saharjo, 2008) causes a lost of 5.4 million ha of forest and land. The provinces of Sumatra and Kalimantan suffer the main lost due to the resulting smoke that also spread to neighbouring countries including Singapore, Malaysia and Brunei. The visibility was less than 500 m in Singapore and the impacts of the smoke only ended on September 1994. The short visibility cause disturbance of flight schedules which resulted in the drastic decrease number of tourists (Saharjo, 2008).

Some of the fire happens on agricultural land. Peat is vulnerable to burning and the relatively long period of combustion cause overproduction of smoke (Saharjo, 2008). The loss of log based on data from MoF was US$ 15.4 million. While the cause of fire was clear-cut-burn activities by logging concessions/industrial forest plantation and plantations, although based on the remarked by the Minister of Forestry at the time, another possible cause was intended burning due to the conflict between local communities and logging and plantation companies.

5. Forest fires in 1997/1998

The 1997/1998 forest fire was the worse fire occurred within the last two decades (Saharjo, 2008). According to ADB, the total burned areas was 9.75 million ha spread across several islands including Sumatra 1.7 million ha, Kalimantan 6.5 million ha, Java 0.1 million ha, Sulawesi 0.4 million ha, and Irian jaya 1 million ha. Based on the type of burned forest were: upland forest 0.1 million ha, lowland forest 3.3 million ha, peat 1.5 million ha, agricultural lands and *Imperata cylindrica* 4.5 million ha, Industrial plantation forest and plantation 0.3 million ha. The cause of fire were: conversion for large-scale business purposes, cultivators, burning by logging concession, burning on agricultural lands, intended burning and negligence (Saharjo, 2008).

6. Recent fires

Recent fires especially for the past 5 years were caused by the land clearance by local people or companies both forest and plantation companies. This became worse when ex-logging concession and ex-plantation areas are used by third parties (Saharjo, 2008). There were increasing environmental impacts due to the internal involvement of some authorities. The results were severe impacts on the people and environment.. Fires happen during 2002, 2004, 2005, 2006, 2007, 2008 and 2009.

7. Greenhouse gas emissions from forest and land fires

All organic materials store carbon. The average amount of stored carbon in organic materials range between 46 % of its dry weight, hence when the trees are burned, they will release a big amount of carbon to the air. Based on data provided by WWF, the 1997-1998 forest fire in Indonesia has released greenhouse emission of 0.81-2.57 Giga tonnes of carbon to atmosphere. On peatlands, there is an accumulation of organic materials due to the slow decomposition rate is compared to accumulation rat of organic materials on forest floor. Globally, Peatlands stored about 329 - 525 Giga tonnes (Gt) of carbon and about 14 % (70 Gt) are found in tropical areas (Murdiyarso et al, 2004). This source of carbon causes the high release of carbon when peatlands are burned, which in turn will result in global warming. Forest fires have placed Indonesia on third place in global CO2 emissions behind USA and China.

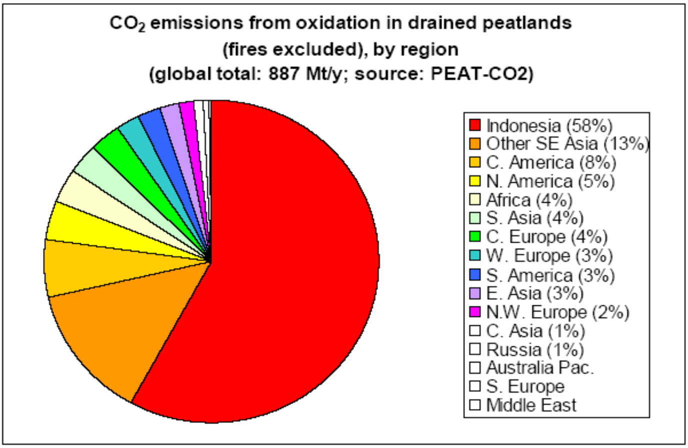


Figure 4.2. CO2 emissions from peatlands in Indonesia and other Southeast Asian countries as compared to emissions from other peatland regions in the world (Hoojier et al, 2006)

The hazard (main danger) of fire incidents or forest and land is the production of smoke with presence of particles (Saharjo, 2008). Flame is the spectacular part of a fire (Debano *et al*, 1998), a common symbol of fire is smoke. Hundreds of elements are produced during the exothermic reaction of combustion. These elements are released through oxidation and to atmosphere. Many of these compounds have high evaporation temperature, as a consequence always ready to condense and become soot, tar and water inside air condenser above fire, causing formation of clouds from visible smokes. The impacts of smoke on environment vary from local that is preventing visibility to global warming (Saharjo, 2008). These impacts are mostly the results of principal chemical products and secondary emission of burning.

Principal chemical products

The principal chemical elements of combustion are easily vaporized elements (but not oxidized) during combustion process, forming partial chain or the whole perfect oxidation from organic fuel materials and forming *pyrosynthesis* throughout the combustion. Some of these products include C_2 and water vapour, are normal elements of atmosphere, but often the other products are air pollutants such as particulates, CO, SO_2, NO_2, and Ozone (O_3).

CO_2

The biggest emission released to the atmosphere as a result of combustion is CO_2. Together with water vapour, CO_2 amounts to 90 % from fire emission where mostly (80-90%) are C emissions. CO_2 is 99 % resulted from C emission from efficient combustion that is combustion that used up the whole most of the fuels, if not all from available fuel materials, but, but only 50% in low intensity *smoldering fire*. The chemical compounds are not air pollutants but greenhouse gases thus have the potentials of causing global warming.

CO

Carbon monoxide (CO) is generally produced through the incomplete burning of humid (wet) fuel materials, including air pollutants. The amount of CO released into atmosphere is a function of combustion efficiency, and increased with a decrease in efficiency (inefficient). The impacts of CO on human health depend on the burning period, concentration of CO and level of physical activity. Fire extinguishers who are directly involved with extinguishing fires would be careful of the impacts of CO such as nausea, tiredness and loss of concentration and orientation.

Particulate

Particulate (Saharjo, 2008) is an important chemical element release by fire due to its impacts on human health and visibility. Emission of particles degrades air quality by reducing visibility and in several cases disturbs human health through breathing disturbance. Distribution of particle size in smoke vary, mostly depending on chemical element and fuel type that was consumed and released heat which are characteristic of each individual fire. Monitoring smoke plume from the air that is generated from vegetation wastes combustion is known to have size of 0.15μm and > 43μm (Radke *et al*, 1990). Bigger particles are in smoke plume that is form de to air turbulence not through burning. Small particles found in plume smoke allow several particles to be carried into the lungs.

Hydrocarbon

Hydrocarbons are released by many combustions (Saharjo, 2008) and are groups of various elements and different in their atmospheric reaction depending on their chemical structure. *Aliphatic hydrocarbon* relatively non-active on the air. This saturated hydrogen compound produce about 15% of hydrocarbon emissions in smoldering fire, and 30 % during flaming phase from one fire incident (Sandberg *et al*, 1975).

Hydrocarbon (Saharjo, 2008) as a group is not considered as criteria of air pollutant, although hydrocarbon traces could impact air quality (reduce visibility) and human health. Hydrocarbon related to air quality and human health are *aldehyde* and *Polynuclear Aromatic Hydrocarbon* (PAH). *Aldehyde* found within smoke will cause eye, nose and stomach irritations. *Aldehyde* also influences the performance of firemen through depression of breathing rate. Aldehyde production in combustion ranges between 0.6 to 2.5 % of fuel weight.

Methane

Methane (Saharjo, 2008) is the third abundant greenhouse gas that contributes to global warming. About 10 % of methane is release into atmosphere each year generated by biomass combustions (Andreae, 1991). Other hydrocarbons that are released into the atmosphere have on the average rate of 70% of methane emissions.

Nitrogen and SO_2
The production of $NO_{(x)}$ from fire mostly depend on the N content of the consume fuel. Both NO and NO_2 are reactive gases that are emitted from fire (Lobart and Warnatz, 1993). Thermal NO is a stable product of combustion. Although NO_2 is not less stable than NO, its abundant will increase in smoldering fire. Conversion of N fuel to $NO_{(x)}$ can vary and about 5 % for wood and close to 40 % for organic soil. There is a linier relationship between N fuel and $NO_{(x)}$ emissions into the atmosphere in the form of smoke plume (Clements and McMahon, 1980). Nitrogen oxide is classified as air pollutants and as a way for ozone formation and other air pollutants. Other nitrogen compounds that are release during combustions are *ammonia*, *nitrite*, *hydrogen cyanide*, *acetronitrile*, nitric acid, amino acids and heterocyclic N.

Sulphur oxide makes S as the principal fire emission. SO_2 is an air pollutant although not really been considered, mostly because of its small fraction in cloud formation. Between 40 to 60 % of S in consumed fuel are left as ash.

A collaboration research between Japan and Indonesia (Saharjo, 2008) was conducted on September 1997 in South Sumatra (peat area) and found that there is an increase of carbon monoxide as much as 40 times, methyl chloride 123 times, methyl bromide 15 times and methyl iodide 43 times. Levine et al., (1999) also reported that fires occurred in Sumatra and Kalimantan in 1997 have increased gases by folds compared to the 1991 explosion of oil refinery in Kuwait, or similar to carbon dioxide gas 2.5 times, carbon monoxide 50 times, methane 8 times, nitrogen 197 times and particles 9 times.

Table 4.2. Type of emissions, amount of gas and particles release during the 1997/1998 fire (Levin et al, 1999).

Emission type	Land use type (vegetation)	Total emissions (million metric tonnes)
CO2	Agriculture	9.234
	Forest Fire	11.080
	Peat	171.170

	Total emission	**191.485**
CO	Agriculture	0.785
	Forest Fire	0.942
	Peat	**31.067**
	Total emission	32.794
NH3	Agriculture	0.10
	Forest Fire	0.12
	Peat	2.563
	Total emission	**2.585**
CH4	Agriculture	0.030
	Forest Fire	0.035
	Peat	1.780
	Total emission	1.845
NOx	Agriculture	0.023
	Forest Fire	0.027
	Peat	5.848
	Total emission	5.898
O3	Agriculture	0.177
	Forest Fire	0.213
	Peat	6.710
	Total emission	7.100
Total particle matter	Agriculture	0.046

	Forest Fire	0.547
	Peat	15.561
	Total emission	16.154

Based on a formula by Seiler and Crutzen (1980), Levine et. al., (1999) has calculated the amount f gas emissions from combustions on agriculture, forest and peatlands in 1997 fro Sumatra and Kalimantan with a total burned areas of 45,600 km2 with the following results: carbon dioxide gas 191.5 million metric tonnes where 171 million metric tonnes originated from peat combustion, carbon monoxide gas 32.8 million metric tonnes where 31 million tonnes generated by peat combustion, methane gas 1.84 million metric tonnes where 1.78 million tonnes generated by peat combustion and particulates 16 million metric tonnes where 15.6 million metric tonnes generated through peat combustion. As a result, the 1997/1998 fire that consumes up to 10 million ha of forest and lands, produced 1 Giga tonnes of carbon dioxide which place Indonesia as one of the largest carbon dioxide producer country in the world since 22% of carbon dioxide products originated from Indonesia.

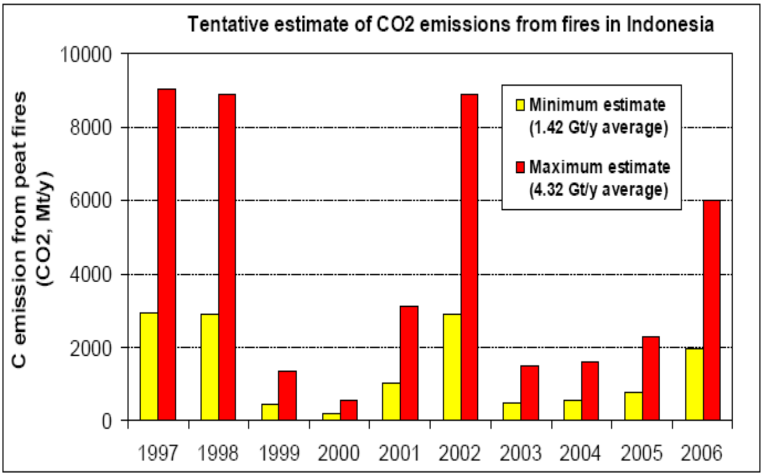


Figure 4.3. Estimation of annual average carbon emission due to peatland fire (Hoojier et al, 2006)

8. Smoke distribution

Figure 4.4. Smoke from forest fire that covers the earth's surface in the afternoon

Smoke distribution (Saharjo, 2008) is very much effected by weather condition especially wind (velocity and direction) and stability of atmosphere (stable, unstable and neutral). On unstable atmospheric condition where air masses from the surface experience uplift and air masses will keep increasing, then smoke will easily spread and mix with air, hence smoke is not trap on the troposphere layer f the atmosphere. This situation is hazardless in seen from the pollution perspective. On stable atmosphere where air masses will be uplifted until certain altitude and down lifted again, hence this will he hazardous because it will lift the smoke and put it down on other areas. This explains why smoke in Indonesia could be carried to neighbouring countries or what is known as **transboundary haze pollution**. On neutral atmospheric condition where air masses is neutral (not uplifted nor down lifted), the resulting smoke will be maintain on the origin of smoke thus is hazardous for human health and disturb activities. Small particles will be carried by wind movement as gases and also through air vertical particle movement (convection) hence can be carried to the upper layer of the atmosphere.

9. Reasons for the occurrence of fires

Fire has been used since 500,000 years ago, but the use of fire commenced only about 20,00 years ago (Johnston, 1970). Various historical records suggest how fire was use then and now (Saharjo, 2008). One example of use of fire is by the Aborigines of Australia. Fire was use to clear dense vegetation to open up roads, regenerate plants suitable for cash crops and use of fire prevention around tents.

For most ecosystems (Saharjo, 2008), fire is a natural catalyst for their diversity and stability. Without fire, forest communities become homogen and allow the existence of similar species, accumulation of fuel materials, stagnation and inappropriate reproduction thus easily attack by pests and diseases.

Currently, fire a management tool that is relatively cheap, easy and quick. Controlled fire can be use to protect land from wild fire and also to eliminate unwanted species to increase diversity within community and other reasons (Saharjo, 2008).

The risk of fire (Saharjo, 2008) will dramatically increased through the conversion of forest into rubber and palm oil plantation, Industrial Plantation Forest and logging in natural forest that open up tree crowns causing dryness of ground cover. Field results suggested that forest fires are easily occurred on secondary damage forest due to previous logging operations.

Logging activities increase the risk of fires and destruction (Mackie, 1984). Accessible roads will allow migrants and local people to enter and use the land. Furthermore, logging activities will cause log accumulations (generated from unused logs). Around 65-80 % of the 1997/1998 forest fire was found on forest concession areas and plantation (Saharjo, 2008). Furthermore, the increase demand of raw materials for pulp and paper which tend to increase by years cause the need for increase and sustainable supplies. To maintain production sustainability, there need to be some alternative raw materials which are renewable and this is through the establishment of Industrial Plantation Forest. Unfortunately, due to high demand of raw materials, the only way to realize this is by preparing land through the use of fire. Furthermore the tradition of using fire to clear land used by shifting cultivators is the only practical way, cheap and quick, thus this kind of land clearing activity will be encounter every dry season/drought. Specifically for those cultivators, there is a tendency that they are not only clearing land for survival but also for business purposes, since the working area covers tenths of hectares and the plant type also change to rubber or palm oil.

Forest fires (Saharjo, 2008) dot not easily occurred since stands/vegetations have certain effective prevention mechanism. Such efforts is done through maintaining the relative temperature and humidity inside the stands thus allowing fuel materials to slowly experience dehydration and distillation and pyrolysis. This is done through establishing dense crown and stands. Through this mechanism, sunlight has difficulty to reach forest floor beyond its normal range, thus reduce the risk of change in temperature, humidity and wind velocity. As a result, the stand will have lower temperature with high humidity thus reduces the occurrence of fire. All of these can only be done if photosynthesis process (by trees and ground cover) can occur without disturbance. For ground cover, the optimum condition for a photosynthesis process could stimulate the growth of micro organism and grow on forest floor allowing decomposition process to take place (Saharjo, 2008).

However, if undisturbed, water availability will decrease due to prolong drought thus ground water level decease and disturb the photosynthesis process (Saharjo, 2008). Under such disturbance, leaves will wither and dry thus relatively easy to burn. As a result, the micro climate under the stands, both above and below the ground changes. Temperature will increase, humidity will decrease and wind velocity will increase. With such changes, the risk of fire is higher. Once rainfall is below 100 mm per month and within two to three weeks without rain, forest vegetation will shed their leaves progressively with increase dry level. Furthermore, water content of surface fuels become low, while woody fuels and litters underneath form layers hat allow the spread of fore on above ground fire. (Goldammer, 1996).

The risk of fire (Saharjo, 2008) will dramatically increase through the conversion of forest materials into rubber and palm oil plantations as well as exploitation of natural forest that open up crowns and lost of ground covers. Plants become drier and trees fill every available space compare to tropical rain forest, which allow fire to spread. There are many proofs that fires are easier to occur on secondary disturbed forest through logging. Selection cutting have damage ground covers and destroy crown that provide cover causing forest fire (WWF, 1998).

This information showed that natural forest (Saharjo, 2008) can get burned if there is a disturbance on the natural processes within the ecosystem causing other disturbances such as photosynthesis process that disturbs the function of plants' organs. One of the factors that can disturb ecosystems is prolong drought or the presence of El-Nino on certain periods (Saharjo, 2008). Ecosystem disturbance can also be caused by human activity through logging such as unregulated logging causing drier micro climate within the stands allowing more pyrolysis process to take place thus increasing the chance of forest fire. According to Fuller (1991) climate and weather can influence forest fires since: 1. Climate determine the amounts of available fuels, 2. Climate determine the length and nature of fire season, 3. Weather regulate water content and ease of fuels to burn and 4. Weather affects the flaming process and spread of fire.

B. Forest Cutting

1. Forest

Forest as an investment in national development provides real benefits for living things including ecological, social, cultural and economical benefits. (Saharjo, 2008). Therefore forest must be managed, protected and utilize sustainably for the welfare of Indonesian people, in this generation and future generations. With regard to its role as a life support system, forest has given significant benefits for human beings. Forest balance global environment thus its position within global level becomes very important although focus should still be on national needs (Explanation of Law of Forestry No.41 year 1999).

Forest resources have significant roles in supplying industrial raw materials, income sources, establishing employment and work opportunities (Saharjo, 2008). Forest products are commodities that can be transform into processing products to get their additional value and open up opportunities for employment and work. Forest products processing should not degrade the forest as the supply of raw materials for industries. In order to maintain balance between the ability to supply raw materials and their processing industries, thus regulation, management and development of upland processing industries for forest products should be regulated by the Minister of Forestry. Forest utilization is not limited only for wood and non-wood products, but must also be extended to utilization of plasma nutfah and environmental services, to obtain a more optimum forest utilization (as explained in Act No.41 of 1999).

2. Deforestation

Based on the integration and harmonization of 1999 Forest Land Use by Consensus (TGHK) – Provincial Spatial Planning (RTRWP), the total natural forest was estimated to be approximately 120,353,104 ha (Purnama, 2003), where 50 million ha was estimated to be the total degraded forest (Haeruman, 2003). Based on satellite imagery, the rate of deforestation of natural forest during 1985 - 1997 was 1.6 million ha/year, during 1997 - 2000 was 2.8 million ha/year and become even more uncontrollable during 2000 - 2003 (Purnama, 2003). As a result, Indonesia has experienced national loss about Rp 30,000 billions. Ironic that a country with rich natural endowments but poor people. Moreover, due to the extensive deforestation, have caused environmental degradation such as flood, drought, fires, pests and diseases, global warming, land slides and erosion that all have contributed to the sufferings of Indonesian community and people (Darusman, 2003). Unfortunately, some of logging licenses were obtained from the government and related authorities and have been happening for years such as in Riau Province.

Based on 2001data from FWI/GFW, it was known that since 1900-1997 especially during the periods of 1985-1997, the Island of Sumatra has lost about 61% of its terrestrial forest or equal to 3,391,400 ha. This was based on an assumption that in 1900 the total forest cover was 16,000,000 ha which decreased to 5,559,700 ha in 1985 and again decreased to 2,168,300 ha by 1997. During the same period, Kalimantan Island has lost 58% of its terrestrial forest and Sulawesi has lost 89%, of which the average lost of terrestrial forest of the three islands on the average was 60% during the periods of 1985-1997.

An interesting issue from the forestry sector is that the deforestation rate in Indonesia is considered very high (SLI, 2008). During the years of 2000-2006 alone, the deforestation rate was about 1.09 million ha/year with the highest rate occurring in Sumatra and Kalimantan. The alarming rate of deforestation is blamed for the occurrence of million hectares of critical lands, estimated to reach about more than 77 million ha both in and out of formal forest areas (SLI, 2008). The biggest critical lands are found in West Kalimantan Province, East Kalimantan and Riau. Deforestation rate during 1982-1990 reached a figure of 900,000 ha/year; year 1990-1997 reached 1.8 million ha/year and year 1997-2000 reached 2.83 million ha/year. During 2000-2005, its rate decreases to 1.09 million ha/year. There are many factors causing the high deforestation rate and land degradation, where change of land use for agriculture/plantation is thought to be the prime factor. Expansion of palm oil plantation in Riau Province made deforestation rate as the highest. For a very long time, land and forest resources have economically contributed great benefits to the country (Saharjo, 2008). Unfortunately, these benefits were exchanged with land and forest resources degradation. Million hectares of critical lands were formed due to the unsustainable utilization of land and forest resources.

By 2007 (SLI, 2008) land transformation into plantation has reached about 4,741,194 ha and settlements for transmigration scheme has reached 956,672.81 ha. Based on the available data, it was known that land use change into plantation in Riau province was the highest reaching a figure of 1,611,859.68 ha and followed by Central Kalimantan with 619,868.37 ha. Demands for agriculture and plantation tend to increase, which indirectly were the results of increased demand for production of certain commodities from agricultural and plantation sectors. In plantation sector, the re is a promising business and prospects of palm oil plantation. This has caused the expansion of palm oil plantation in several places in Indonesia. In 2006, the production of palm oil reached a total of 16,080,000 tonnes; 3,800,000 tonnes for national consumption and 12,101,000 tonnes for exports. Indonesian palm oil production has contributed about 41 % of world's imports that totalled to 29,178,000 tonnes.

Indonesian government has targeted that by 2010, about 10% of all the national fuel requirements will be supplied through Biofuels; 70% will be based on palm oil or known as biodiesel (SLI, 2008). In order to meet this requirements, there has to be an increased of supply or productivity of palm oil in big amount. Thus the government through the Ministry of Agriculture has targeted expansion and replanting of palm oil under the plantation revitalization program for year 2007-2010 as much as 1,375 million ha (expansion) and 125,000 ha (replanting).

C. Animal Husbandry

Prior to industrial era (Tampang, 2009) human activities did not contribute much to greenhouse gases. Unfortunately, increase in human population, forest clearance, animal husbandry, industries and use of fossil fuels have resulted in the increase of greenhouse gases in the atmosphere and contribute to global warming. Animal husbandry alone has contributed about 9 percent of carbon dioxide, 37 percent of methane gas (has warming effects of 72 times stronger than CO2 within 20 years, and 23 times within 100 years), and 5 percent of nitrogen oxide (has warming effect of 296 times stronger than CO2). Animal husbandry also produces ammonia through human activities that resulted in acid rain (www.pbbn.or.id).

The transformations of land into husbandry including transformation of land into grassland and for grazing areas as well as forest clearance for husbandries have contributed about 2.4 trillion tonnes of CO_2 annually (Tampang, 2009). Methane gas that is release during the process of animal digestion could reach up to 86 million tonnes annually while methane released from animal wastes could reach 18 million tonnes annually.

V. CARBON STORAGE IN PEATLANDS

Plant biomass increases because plants absorb CO_2 from the atmosphere and alter it into organic matter through photosynthesis process (Whitmore, 1985). Estimation of vegetation biomass can provide information on the amount of carbon and nutrients stored in vegetation. To calculate vegetation biomass in a tree is not easy. According to Haygreen and Bowyer (1996), biomass is determined by multiplying volume with wood density.

Carbon calculation, according to Booth (2003) is a process of estimating the amount of carbon found on different parts of a system. This is done to estimate the amount of carbon that can be traded or used as data to reduce greenhouse gas emissions. There are two principal methods of carbon calculation, *i.e.*, direct calculation by calculating the amount of carbon in a tree, litter and soil or by using a model to estimate the stored carbon within a system.

Each tree species has different ability to absorb carbon due to their typical differences in the ability to absorb sunlight, water level and soil fertility that are affecting photosynthesis. Carbon is stored in dead materials such as litters, log, fallen trees decayed (Whitmore, 1985).

The reduced carbon concentration in the atmosphere occurs through photosynthesis process by green plants. Photosynthesis is defined as the conversion of CO_2 and H_2O into sugar using chlorophyll and the energy from sunlight. Photosynthesis is the assimilation of carbonic compounds where organic compounds such as CO_2 and H_2O are converted into $C_6H_{12}O_6$ molecule using the energy from sunlight and chlorophyll. On converted lands that are experiencing degradation, carbon emissions can be reduced by replantation to trap increased soil carbon emission through photosynthesis (Brown et al., 1993).
Our atmosphere consists of 60,249 x 10^{15} carbon molecules comprising of 59.9 x 10^{12} CO_2 molecules; 0.33 x 10^{15} CH_4 molecules and 0.19 x 10^{15} CO molecules. Carbon emission occurs during several activities such as: 1) plant, animal and human respiration, 2) fossil fuels combustion such as kerosene, coal etc, 3) forest fires and 4) volcano eruption.

Basically, carbon (Soedomo et al., 2001) is generated through anthropogenic and natural activities. The main source of CO_2 is organic materials from micro-organism activities, gas exchanges on sea, forest cutting, respiration by animal, human and fossil fuels combustion. Anthropogenic activities such as industries, use of fossil fuels and land transformations (cutting, land clearance and huge forest fires are the principal sources of carbon emissions).

A preliminary study estimated that the decomposition of peatland and peatland combustion in Indonesia amounts to 2000 Mt CO_2/year, where most are cause by deforestation (Uryu et al., 2008).

A. Peatland

Peat swamp forest (Saharjo, 2008) is a type of forest with specific conditions where the peat is formed from previous forest generation's remains. Peatlands are areas formed from an accumulation of partially decayed dead ancient plant materials, comprising of a minimum of 12-18 % C-organic with minimum depth of 50 cm. Peat has double meaning, that is peat as organic material (peat) and organic soil (peat soil). Peat and peat soil have different functions. Peat as organic material is source of energy, medium for plant growth or organic fertilizer, while peat as organic soil is used for agricultural purposes and can be manage within agricultural system (Andriesse, 1988).

There are three known organic materials based on decomposition level of the parent materials, *i.e.,* fibric, hemic and sapric (Saharjo, 2008). Fibric is generally has a bulk density of less than 0.1 g/cm3, fibre content of 2/3 of its volume, and water content during saturation ranges between 850 % to more than 3000 % based on oven dry weight, colour is generally yellowish brown, dark brown or reddish brown. Hemic has a moderate decomposition level, with bulk density between 0.07-0.18 g/cm3 and normal fibre content between 1/3 – 2/3 of its volume. Maximum water content during saturation ranges between 250-450 %, greyish brown to dark reddish brown in colour. Sapric has a bulk density bigger than or equal to 0.2 g/cm3 and average fibre content less than 1/3 of its volume. Maximum normal water content during saturation is less than 450 % and dark grey to black in colour. The total peatland area in Indonesia varies, some estimate about 18.4 million ha and some estimate about 15.5 million ha where 10.5 ha occur on tidal swamp agroecosystem and 4.99 million ha occur on valley swamp agroecosystem. Typical of peat is the low pH (3-4.5), relatively low organic matters compared to mineral soils especially P and K, and irreversible drying property, meaning upon drying, the peat will not returned to its original form (similar when the peat is combusted, it will not go back to its original form due to the damaged peat).

Tropical peatland comprises 10-15 % of all global peatlands estimated to be 400 million ha with relatively greater depth and may store about 70 Gt or about 20 % of all soil carbons (Immirzi and Maltby, 1992). The extent of peatlands in Indonesia ranges between 16.5-27 million ha, an estimation that reflects the different definition related to its thickness (Sugandhy, 1997). The dominant peatland and peat swamp areas in Sumatra, Kalimantan and Papua make up approximately 99.5 % of all peatlands in Indonesia; Sulawesi with 340,000 ha (0,2%) and Maluku with 42,000 ha (0.25%). In Sumatra alone, peat ecosystem dominates an area of 4.6 million ha along the eastern coast of North Sumatra to South Sumatra. In Kalimantan, peatland dominates 3.5 million ha especially on the western coast of West Kalimantan, middle part of Central Kalimantan and on several parts on East Kalimantan. In Papua, peatland dominates most of the southern coast and some on south-western coast with a total area of 8.7 million ha (Sugandhy, 1997).

There is a general classification of peat based on depth, where less than 100 cm is classified as shallow peat, between 100-200 cm as moderate peat and more than 200 cm as deep peat (Radjagukguk, 1992). Nevertheless, there is no information of any peat areas that are included under this category. Depth of peat varies between 0.5 m to more than 10m. The average depth of peat is not known, 3 meter maybe considered too low but 5 meter seems unlikely (Rieley et al., 1997). There are two main categories of peat in Indonesia, topogenous and ombrogenous. Topogenous peat is often found in swamp areas where there is an accumulation of shallow organic materials (< 50 cm). The area is inundated by river water during rainy season when they receive nutrients to maintain forest biomass sustainability. Ombrogenous peat is the true peat swamp (organic materials > 50 cm), where water and nutrients supplies are only obtained from the air such as aerosol, debris and rainwater; they are situated far from river bodies and mengangkangi flow areas between water catchments.

In Indonesia, the lowland peat swamp supports forest vegetation, although some have been degraded and on upland peat are dominated by sedge and pandan thickets (Saharjo, 2008). Peat swamps forest consists of a catena of forest types which replace each other from the swamp perimeter near to rivers and their tributaries to their centre (Dilmy, 1965; Anderson, 1963); this change reflects variations in peat depth, water logging and nutrients availability for tree growth. The principal characteristics of this zonation is replacement of the higher canopy forest of the edge zone (35-40 m high) by a denser, lower growing pole forest in which tree diameters rarely exceed 30 cm and the canopy of which is less than 20 m high (Anderson, 1963). Trees of the low pole forest show an increasing tendency to xeromorphism and chlorosis of their foliage. Whilst peat swamp forest vegetation is less diverse than dry land rain forest, it has been recognised as an important reservoir of plant diversity in Southeast Asia (Whitmore 1984). The tree diversity varies from only 30-50 spp. ha-1 in the low pole forest up to 240 spp. ha-1 in the mixed swamp marginal forest (Anderson 1963).

1. Forest and Peat Conversions

There is a limited commercial use of forest and forest land resources up to the middle of this decade (Saharjo, 2008). The most drastic change occurred when the Law of Forestry was issued in 1967.

Million hectares of forest land have been given licences as forest concession areas at the end of 1960s and early 1970s became the leading wood booming in Sumatra and Kalimantan that alter the spatial planning of the two islands for more than two decades. Government policies and allocation procedures and forest concession supervision are not regulated and full of corruption that resulted in serious impacts of forest ecosystem, biodiversity and people inhabiting the forest. Forest management and land use practice in Sumatra and Kalimantan have developed rapidly fro these past three decades (Scweithelm, 1998). Indonesian forests have been exploited at the rate of 40 million m3 per year, a rate that is almost twice the recommended rate by the Minister of Forestry for sustainable yield (UNCHS, 1999). Based on landsat imagery, in 2000 less than 101.73 million ha out of the total forest and land areas have been degraded where 59.62 million ha are forest where 10.52 million ha are in protection forest; 4.69 million ha in conservation forest and the rest about 44.42 million ha in production forest. The deforestation rate during 1985-1997 was estimated to be about 1.6 million ha/year, during 1997-2000 increase drastically about 3.8 million ha/year and during 2000-2003 was difficult to estimate due to difficulty in monitoring (Purnama, 2003) or estimated to be around 2.8 million ha/year.

2. Commercial Use of Peat

There is wide spread and unabated conversion of peatland for agriculture and forestry (Maltby et al., 1996). Other forms of conversion such as mining for energy or horticulture and aquaculture are much more limited and mainly experimental. In Indonesia, 3.72 million ha (18% of the total peat swamp forest) have had some forms of development (Silvius and Giessen, 1996) of which at least 500.000 ha have been cultivated by the transmigration farmers (Notohadiprawiro, 1996). Much of the land cleared for agriculture has been abandoned subsequently for a number of reasons which derived from a consideration of the hydro physical and biochemical properties of peat and socio-economic limitations to sectoral development of peatlands (Maltby et al., 1996). About 20% of peat swamps in Indonesia have been developed mostly for agriculture, a sector that influences the remaining peat swamp forest resource (Rieley et al., 1997). Extensive use of peat swamp areas have resulted in mush of it being deforested and drained under

Indonesia government and foreign aid-funded programs whilst an additional large area has been occupied by spontaneous settlers (Rieley et al., 1997). A large population and high pace of economics development, have increased pressure for the development of tropical peatland for different land use.

3. Fires in Peatland

Peat is a type of fuel that is found below the ground, therefore it is one of the fuels forming ground fuels (Saharjo, 2008). Ground fuel has higher water content compared to above ground fuels (litters, twigs and log) and crown fuels (tree crown, leaves, moss and epiphytes). If ground fire occurs, the spread of fire will be slow because it is not effected by wind (found below ground), causing uneven distribution of fire and difficulty in detecting where the fire might occur. The only thing that is seen is the white smoke on the surface. This type of combustion is known as smoldering combustion that is combustion without the help of oxygen (wind).

Ground fire does not appear on its own (Saharjo, 2008) but very often initiated with surface fire. Due to surface fire, heat will penetrate to lower surfaces through the pores of the peats, burned logs and roots of shrubs where the upper parts have been burned. Heat (Saharjo, 2008) can penetrates below the ground if the peat water content is sufficiently low thus allowing combustion to occur, but if the water content is high, heat penetration will be inhibited. Therefore, surface fires can transform into ground fires due to lower water content within the peat. It is understandable why particular traditional communities are reluctant to burn peatlands during dry period, since such activity would be be harmful because depth of the burning peat will increase as compare to burning during rainy season (although not dense). While for palm oil companies, they can regulate the height of the water level through canals that they established.

Smoldering phase normally follows flaming combustion, although slowly (< 3 cm/hour) and flameless (Saharjo, 2008). Smoldering is the initial combustion phase in these fuel types (peat) while on fire consuming non-peat fuel is tahapan penyalaan (filled with oxygen). There are two zones characterizing this smoldering phase: 1) a pyrolysis zone with evolving combustion products and 2) a charcoal zone with no visible combustion product release. The rate of fire spread decreases because the fuels are not able to supply combustible gases in concentrations and at rates needed to support vigorous combustions. Subsequently, heat release declines and temperature drop, causing larger amounts of gases to condense into smoke. Smoke persists near the ground in high concentrations and atmospheric emissions double or triple over those released during the flaming phase (Johansen et al, 1989). Particulate product emissions during the smoldering phase are greater than those of the flaming phase. An increasing proportion of smoldering during flaming combustion can result in a doubling or tripling of the particulate (Debano et al, 1998). When smoldering combustion dominates, the volatile gas and vapour products that are characteristic of pyrolysis in the pre-ignition and the flaming phases cease to evolve. Particulate emissions can then increase tenfold and charcoal builds up on the surface of woody fuels when smoldering predominates.

The above information suggest that burning peatland (Saharjo, 2008) will occur slowly (resulting in a complex management), with imperfect combustion process (lack of oxygen) forming more gases as compare to burning process where the flaming is more dominant (Saharjo, 2008). This occurs because peats (organic materials) found below ground have different decomposition level (fibric, hemic dan sapric) with high water content.

According to Usup et al., (2001) there are two types of peatland fire in Central Kalimantan; the first type is ground fire that occur on upper layer of the peat on depth of 10-20 cm with spreading rate of 3.8 cm/hour; and the second type occur on the peat layer on depth of 20-25 cm with spreading rate of 1.3 cm/hour.

Most tropical fires are set or spread accidentally or intentionally by humans and are related to several causative agents; some of them limited to subsistence livelihood, others to commercial activities (Qadri 2001). Foremost among the various underlying causes of catastrophic fires in Southeast Asia in 1997-1998 are the uses of open burning techniques for conversion of forestland to other land use, e.g., estate crops, industrial plantation and other commercial enterprises, traditional slash-burn agriculture and speculative burning to stake land claims (Qadri 2001).

Forest plants communities are important in regulating regional, local and global climate (Saharjo, 2008). At local level, trees provide protection and regulate water that provides cooling effect during hot weather. Trees also act as barrier of storms and reduce the lost of heat energy in cold season. At regional level, water evaporation from trees is release to atmosphere and return as rain. The lost of vegetation in areas such as the Amazon and West Africa could reduce the average regional rainfall. At global level, plant growth relates to carbon cycle. The lost of vegetation would reduce the absorption of carbon dioxide that resulted in greenhouse effect. Plants also produce oxygen necessary for animals and human beings (Primack *et al.,* 1998).

In Riau Province, one of Indonesia provinces in Sumatra (Saharjo, 2008), most of the smoke produced recently, are due to land preparation using fire for palm oil and plantation forests. Sumatra is home to approximately 6.3 million ha or 33% of Indonesia tropical freshwater wetlands (RePPProT, 1996). These inlands freshwater wetlands include both peat and alluvial swamps. With dry land areas already extensively developed, the wetlands of Sumatra are increasingly the focus of economic activities, including large-scale forestry and oil palm plantations, particularly in Riau and North Sumatra. The companies believed (Saharjo, 2008) that peat lands are suitable for large-scale tree plantation because they are vast and largely uninhabited, with few land claims, unlike the dry land areas. Forestry plantation companies in Riau covered about 1.5 M ha where peat lands included in, while oil palm plantation is covered about 3.13 M ha which 390.000 of it was in peat (Saharjo, 2008). Recently, worst situation appeared in several district governments mostly in Riau province. The opinion made by the companies that wetlands is suitable for oil palm plantation is followed by the District Government's collaboration with oil palm companies to open the peat land areas with ambitious plan that is to open, e.g., 40,000 ha for oil palm plantation that unfortunately using fire for the land preparation.

South Sumatra province receives large influxes of transmigrants since 1969 and around 30,000 ha of pristine coastal peat swamp forest were reclaimed by chainsaw, drainage and fire to accommodate many of the new arrivals (Dis 1986). At least 28,000 ha people were settled on tidal swamp schemes to the north and east of Palembang (Danielsen and Verheugt 1990). Intended for tidal rice cultivation, the schemes were conspicuously unsuccessful and in many cases failed completely. The drainage has caused a marked reduction in the dry season water table over large areas, and this, together with the grassland and shrub vegetation that replaced the forest, has substantially increased fire risk that is low in the undisturbed ecosystem (Bowen et al., 2000). Extensive legal and illegal logging has devastated widespread areas and increased fire risk in others parts of the swamps. Some of the most heavily exploited areas are now being planted to pulp and timber species. The use of fire to clear the land is standard, and in 1997 one logging company that had applied to government for authorization to convert to pulpwood estate, systematically burnt 40,000 ha of peat land in anticipation of approval (Nicolas and Bowen 1999). The growing of sonor rice is a tradition of people living along rivers in the wetlands of South Sumatra and has now been taken-up by transmigrants (Bowen et al., 2000). It is practiced only at the end of at least a three months drought when long-straw local rice varieties are direct-sown into a rising water table. The crop is harvested by boat. The dangers come from the fires set to clear the land. The farmer's prospect to find most fertile soils and clear up to five times more land than is sown, wildfires are inevitable consequences (Bowen et al., 2000). It had been reported that in 1997 alone at least 75,000 ha were cleared for sonor alone in South Sumatra (that is still practiced until today) while the total of coastal wetlands burned was 500,000 ha. Bowen et al., (2000) identified that the source of fire in South Sumatra mostly from commercial logging which produced high fuel load, forest conversion and shifting cultivation.

In Jambi there was about 341,000 ha of peat or 7.4 % of all peats in Sumatra and 162,700 ha is found within Berbak National Park. Unfortunately, due to illegal logging and fire, only 30 % of the area are currently left as forest (Lubis and Suryadiputra 2004). Mega rice project in Central Kalimantan was one of the best examples where more than 1 million ha of peat swamp forest had dissapeared.

4. Carbon storage in peatland

It is estimated that peatland stored about 25-30% out of the total terrestrial carbon or equal to 550,000-650,000 million tonnes of CO_2 or 75% of the atmospheric carbon or 100 years of fossil fuel emission. Therefore, peat helps in preventing global warming for more than 10,000 years through absorbing 1,200 billion tonnes of CO_2 (Murdiyarso, 2005).

The majority of soil carbon found in peatland ranges between 329-528 Gt (Graham, 1991; Immirzi dan Maltby, 1992; Page et al., 2004). This means that 20% of global soil carbon can be found in peatland (Page et al., 2004).

When wetland is drained to be converted into agricultural land or other land use, the soil will be exposed to oxygen. The carbon content that is resistant to decay under anaerobe prevalent within wetland could be lost through respiration under aerobe condition (Minkkinen dan Laine, 1998 in Watson et al., 2000).

A collaboration research between Japan and Indonesia (Saharjo, 2008) was conducted on September 1997 in South Sumatra (peat area) and found that there is an increase of carbon monoxide as much as 40 times, methyl chloride 123 times, methyl bromide 15 times and methyl iodide 43 times. Levine et al., (1999) also reported that fires occurred in Sumatra and Kalimantan in 1997 have increased gases by folds compared to the 1991 explosion of oil refinery in Kuwait, or similar to carbon dioxide gas 2.5 times, carbon monoxide 50 times, methane 8 times, nitrogen 197 times and particles 9 times. Based on calculation using the formula by Seiler and Crutzen (1980), Levine et al., (1999) has calculate the amount of gas emissions that was released by fires occurring in agriculture, forest and peat in 1997 in Sumatra and Kalimantan with a total of burned areas of 45,600 km2 with the following results: carbon dioxide gas 191.5 million metric tonnes where 171 million metric tonnes originated from peat combustion, carbon monoxide gas 32.8 million metric tonnes where 31 million tonnes originated from peat combustion, methane gas 1.84 million metric tonnes where 1.78 million tonnes originated from peat combustion and particle materials 16 million metric tonnes where 15.6

million metric tonnes originated from peat combustion. Hence, the 1997/1998 forest fires resulted in the destruction of 10 million ha of forest and land producing about 1 Giga tonnes of CO_2 that put Indonesia as one of the largest carbon producers in the world since 22% of world's carbon was produced by Indonesia. However, early November 2002, a script in a recognized journal, "Nature" reported that the 1997/1998 Indonesian forest and land fires have released 2.6 trillion carbons into the atmosphere that is far from the previous estimation of 1 trillion tonnes in 1999. With 1 trillion tonnes, Indonesia ranks first as the largest carbon producer in the world with 22% of world's carbon resulted from Indonesia 1997/1998 fires. For comparison purpose, human activities during 1990s produced an average of 6 trillion carbons annually. A production of 2.6 trillion tonnes of carbon is equal to 13-40 percent of global carbon production. This indicates that fires on peatland resulted in more hazards thus require early preventions.

Using a satellite image of a 2.5 million ha land area located on the 1 million ha ex-PLG (ex-mega rice Project) in Palangkaraya, Central Kalimantan before and after the 1997 fire, Page et al., (2002), finds that 0.73 million ha (91.5%) out of the total 32 % (0.75 million ha) of burned area was peat. Based on field calculation on various peat depths, it is estimated that about 0.19-0.23 Giga tonnes (Gt.) of carbon that was released into the atmosphere during combustion and other 0.05 Gt. carbon from vegetation burning that burns the surface. By using extrapolation based on the above figures, it can be estimated that the carbon release during combustion process in Indonesia in 1997 ranged between 0.81 to 2.57 Gt. The total amount of carbon released during Indonesia 1997 fire is more or less equal to 13-40% of the average annual global carbon emissions originated from fossil fuels.

Due to gas emissions during activities such as deforestation, forest and land fires and drainage, have placed Indonesia as the third largest producer of greenhouse gases after South America and China (Hoojiers et al., 2006). Nevertheless, if gas emission on peatland is not counted, then Indonesia's position drops to 21. Forestry activities contributed the most in terms of gas emission, where in Indonesia, it is about 75% of all gas emissions which reaches an amount of about 3 Gt (Peace, 2007), where 57 % originates from deforestation and conversion where forest and land fires are the main causes.

B. Biomass and Carbon Storage

Biomass is the total amount of living organic materials that is stated in oven dry weight per tonne per unit area (Brown, 1997). According to Whitten et al., (1987), forest biomass is the total amount of dry weight of all parts of living plant, whether for all or parts of organism, production or community and is stated in dry weight per unit area (tonne/ha). Chapman (1976) stated that biomass is the total weight of organic materials of an organism per unit area on a particular place, and weight of organic materials is often stated in dry weight or sometimes in ash free dry weight. Thus, the unit for biomass is gr/m2 or kg/ha or tonnes/ha. The biomass production rate is the rate of accumulated biomass at certain time, thus the unit is stated in per unit time, such as kg/ha/year.

Biomass can be differentiated into two categories, above ground and below ground biomass. The main storage of carbon in a plant is the upper parts that include stem, branch, twigs, leave, fruit, flower and lower parts that include root, dead organic materials (necromass), soil and those stored in the form of wood product that will be emitted in the form of long term product (Brown et al., 1998). Atmosphere acts as a medium in carbon cycle. The flow of biotic carbon between atmosphere and forest/land is the net fixation of carbon through photosynthesis process (net primary productivity) and heterostophic respiration (decomposition on soft and course litters, dead roots and soil carbon). For land areas, it is the process of regrowth and recover, whereas for forest, it is a natural growth. Some of the fixed carbon from photosynthesis will be transferred to water system through stream as absorbed organic materials and the amount for wet tropical area is estimated to be approximately 0.1 x 10^{-6} million tonnes of C/ha/year (Brown et al, 1998).

The whole organic materials or biomass can be use for fuels with various means. Biomass is formed from carbohydrate compounds that consist of carbon, hydrogen and oxygen of which all are produced by photosynthesis (White and Plaskett, 1981). Plant biomass increases because plant absorbed CO_2 from the air and changes it into organic materials through photosynthesis. The rate of biomass fixation is called gross primary productivity, which is dependent on the leave area that receives sunlight, light intensity, temperature and specific plant characteristics. Remain of respiration product is called net primary production (Whitten et al., 1990) or simply means that biomass is the difference between photosynthesis product and consumption through respiration and logging process.

According to Soerianegara (1964), uncontrolled logging activities cause forest degradation/changing of forest environmental condition from climax (primary) into unstable condition (ex-logging). The resulting ecological impacts from such degradation cause the reduction in productivity (biomass), biological diversity and disturbance of ecosystem stability. As stated by Whitten et al., (1987), unwise forest management such as forest clearance and change of land use will reduce biomass.

1. Above ground biomass on peatland

Based on a research conducted by Siregar et al., (2004) the average biomass of stands in peat forest of Central Kalimantan totalled to 582,820 tonnes/ha; root biomass is 179,922 tonnes/ha and ground storey biomass is 45,340 tonnes/ha totalling to an average of 808,082 tonnes/ha above ground biomass of peat forest (Table 5.1).

Table 5.1. Estimation of above ground biomass per ha of peat forest in Central Kalimantan (Siregar et al., 2004).

No.	Component	Plot 1 (tonnes/ha)	Plot 2 (tonnes/ha)	Plot 3 (tonnes/ha)	Average (tonnes/ha)
1	Stand biomass	904,416	358,517	485,528	582,820
2	Root biomass	122,848	163,381	163,381	179,922
3	Ground cover biomass	34,575	33,548	33,548	45,340
	Total	1.061,839	679,949	682,457	808,082

A research was carried out in Central Kalimantan to determine the amount of below ground biomass in peat forest (Siregar et al., 2004) using 3 (three) plots on 5 (five) different depths that vary between 310-384 cm (Table 5.2).

Table 5.2. Peat depth in the study area in Central Kalimantan (Siregar et al., 2004).

Plot	Sub-plot	Depth (cm)
I	1	334
	2	327
	3	338
	4	320
	5	330
Total		1.649
Average		329,8
II	1	308
	2	337
	3	316
	4	330
	5	313
Total		1.604
Average		320,8
III	1	370
	2	380
	3	370
	4	374
	5	384
Total		1.878
Average		375,6

On the same peatland (Siregar et al., 2004), it was known that the average below ground biomass of peat with depth of 0-30 cm, 0-100 cm and 0-300 cm are 8,380 tonnes/ha, 116,447 tonnes/ha and 534,360 tonnes/ha respectively (Table 5.3).

Table 5.3. Estimated below ground biomass of Central Kalimantan (Siregar et al., 2004).

No.	Depth (cm)	Plot 1 (tonnes/ha)	Plot 2 (tonnes/ha)	Plot 3 (tonnes/ha)	Average (tonnes/ha)
1	0-30	6,756	11,712	6,672	8,380
2	0-100	108,48	135,12	105,74	116,447
3	0-300	534,36	534,36	534,36	534,360

The total above and below ground biomass of peat forest in Central Kalimantan (Siregar et al., 2004) on depth of 0-30 cm is 816,462 tonnes/ha; total above ground biomass on depth of 0-100 cm is 924,529 tonnes/ha and above ground biomass on depth of 0-300 cm is 1.342,442 tonnes/ha (Table 5.4)

Table 5.4 Total biomass of peat forest in Central Kalimantan (Siregar et al., 2004).

No.	Component	Plot 1 (tonnes/ha)	Plot 2 (tonnes/ha)	Plot 3 (tonnes/ha)	Average (tonnes/ha)
1	Above ground biomass	1,061.839	679.949	682.457	808.082
2	Soil	6.756	11.712	6.672	8.380
	Total (0-30 cm)	1,068.415	691.661	689.129	816.462
3	Soil	108.48	135.12	105.74	116.447
	Total (0-100 cm)	1,170.319	815.069	788.197	924.529
4	Soil	534.36	534.36	534.36	534.36
	Total (0-300 cm)	1,596.199	1,214.309	1,216.817	1,342.442

2. Carbon storage

Based on a research conducted by Siregar et al., (2004) on peat forest in Central Kalimantan, it was known that the average above ground carbon storage is 521.703 tonnes/ha; if added together with below ground stock on depth of 0-30 cm, the total carbon storage is 526.541 tonnes/ha; on depth 0-100 cm is 588.564 tonnes/ha and on depth 0-300 the carbon storage is 796.401 tonnes/ha (Table 5.5).

Table 5.5 Total carbon storage of peat forest in Central Kalimantan (Siregar et al., 2004)

No.	Component	Plot 1 (tonnes/ha)	Plot 2 (tonnes/ha)	Plot 3 (tonnes/ha)	Average (tonnes/ha)
1	Above ground biomass	681,791	413,191	470,128	521,703
2	Soil	3,901	6,764	3,85	4,838
	Total (0-30 cm)	685,692	419,955	473,978	526,541
3	Soil	62,133	77,866	60,585	66,861
	Total (0-100 cm)	743,924	491,057	530,713	588,564
4	Soil	274,698	274,698	274,698	274,698
	Total (0-300 cm)	956,489	687,889	744,826	796,401

On other types of land use such as ex-logging, ex-burned and *Imperata cylindrica* areas, it was known that the carbon storage varied (Siregar et al., 2004), *i.e*., 216.04 tonnes/ha, 187.725 tonnes/ha and 9.661 tonnes/ha respectively. The total above and below ground carbon storages for the three land use types are also varied. For ex-logging areas, the total above ground carbon storage on depth 0-30 cm, 0-100 cm and 0-610 cm are 413.972 tonnes/ha, 970,359 tonnes/ha, and 4,263.339 tonnes/ha respectively. For ex-burned areas, the total above ground carbon storage on depth 0-30 cm, 0-100 cm and 0-610 cm are 411.349 tonnes/ha, 1,065.056 tonnes/ha and 4,036,986 tonnes/ha. The total above ground carbon storage on depth 0-30 cm for *Imperata cylindrica* area is a little bit lower compare to the previous two areas, that is 252.855 tonnes/ha whereas for depth of 0-100 cm and 0-580 cm, the carbon storages 746.399 tonnes/ha and 3,613,507 tonnes/ha respectively (Table 5.6).

Table 5.6. Carbon storage on ex-logging areas, ex-fire areas and *Imperata cylindrica* in Central Kalimantan (Siregar et al., 2004).

No.	Land use type	Carbon storage above ground (tonnes/ha)	Carbon storage below ground		Total carbon storage (tonnes/ha)
			Depth of peat (cm)	Carbon storage (tonnes/ha)	
1	Ex-logging areas	216,04	0-30	197,392	413,972
			0-100	754,393	970,359
			0-350	2747,515	2963,565
			0-420	2979,354	3195,393
			0-500	3743,422	3959,462
			0-610	4407,299	4263,339
2	Ex-fire areas	187,725	0-30	223,6237	411,349
			0-100	877,331	1065,056
			0-350	2663,98	2851,785
			0-420	3082,75	3270,475
			0-500	3240,627	3428,352
			0-610	3849,261	4036,986
3	*Imperata cylindrica*	9,661	0-30	241,1935	252,855
			0-100	736,7379	746,399
			0-350	2607,478	2617,139
			0-420	3270,751	3280,412
			0-580	3603,846	3613,507

Based on literature studies (Table 5.7) on carbon storage on peatland with water table more than 25 cm (Verwer et al., 2008), it was known that the above ground carbon storage of wet tropical forest (Lasco, 2002) in average was 323 t C/ha, while in Sumatra it is 250 t C/ha (Murdiyarso and Wasrin, 1995). The Net Primary Productivity (NPP) in peat swamp forest is 25 t C/ha/year (Murdiyarso dan Wasrin, 1995) while the Net Ecosystem

Productivity (NEP) in primary peat swamp forest is 5.32 t C/ha/year (Suzuki, 1999).

On peatland (Table 5.7) with table more than 25 cm it was known that the above ground carbon storage of disturbed tropical forest is 181 tonnes/ha (Lasco, 2002), GPP (Gross Primary Productivity) for Central Kalimantan is 34.34 tonnes/ha/year (Hirano et al., 2007) and NEP (Net Ecosystem Productivity) is -4.33 tonnes/ha/year (Hirano et al., 2007).

Table 5.7. Carbon budgets (without inserting the available below ground carbon) from undisturbed and disturbed peat forests and palm oil plantation in several locations in Southeast Asia based on literature studies (Verwer et al, 2008).

Peat with water table > 25 cm	**Total**	**Unit**	**Source**	**Location**
Above ground carbon storage	323	t C/ha	Lasco (2002)	Average wet tropical rain forest
	250	t C/ha	Murdiyarso and Wasrin (1995)	Sumatra
CO2 emissions from soil and root respiration	9,55	t C/ha/year	Jauhiainen et al (2005)	Central Kalimantan
	10,64	t C/ha/year	Muruyama and Bakar (1996)	Western part of Johor
	9,28	t C/ha/year	Jauhiainen et al (2005)	Recovering forest
NPP (Net Primary Productivity)	25	t C/ha/year	Murdiyarso and Wasrin (1995)	Peat swamp forest
NEP (Net Ecosystem Productivity)	5,32	t C/ha/year	Suzuki (1999)	Peat swamp primary forest

	5,22	t C/ha/year	Suzuki (1999)	Peat swamp secondary forest
	1,62	t C/ha/year	Henson (2005)	Undisturbed peat swamp forest
Peat with water table < 20 cm	**Total**	**Unit**	**Source**	**Location**
Above ground carbon storage	181	t C/ha	Lasco (2002)	Average for disturbed tropical forest
CO2 emissions from soil and root respiration	21	t C/ha/year	Melling et al (2005)	Sarawak
GPP (Gross Primary Productivity)	34,34	t C/ha/year.	Hirano et al (2007)	Central Kalimantan
NEP (Net Ecosystem Productivity)	-4,33	t C/ha/year.	Hirano et al (2007)	Central Kalimantan

Based on a research on primary dry land in Jambi, it was known that the above ground carbon storage was 252.34 tonnes/ha, on secondary dry land was 58.07 tonnes/ha (Prasetyo et al., 2000) while the above ground carbon storage from primary dry forest land in Nunukan was 230.1 tonnes/ha and secondary dry forest land was 58.0 tonnes/ha (Lusiana et al., 2005). The carbon storage for shrubs in Nunukan was 19.4 tonnes/ha (Lusiana et al., 2005), while the above ground carbon storage for shrubs in Jambi was 15.0 tonnes/ha and for grasslands was 6.0 tonnes/ha (Prasetyo et al., 2000).

Table 5.8 Carbon storage above ground on forest and non-forest areas

No.	Land cover	Carbon (T C/ha)	Source
	Forest		

1	Primary dryland forest in Jambi	252.34	Prasetyo et al., (2000)
2	Secondary dryland forest in Jambi	58.07	Prasetyo et al., (2000)
3	Primary dryland forest in Nunukan Regency	230.1	Lusiana et al., (2005)
4	Secondary dryland forest in Nunukan Regency	58.0	Lusiana et al., (2005)
5	Primary forest in Sumatra	300	Lasco (2002) in Lusiana et al., (2005)
6	Primary mangrove forest in Nunukan Regency	176.8	Lusiana et al., (2005)
7	Plantation forest	124.4	Handayani (2003)
	Non forest		
1	Shrubs in Nunukan Regency	19.4	Lusiana et al., (2005)
2	Shrubs in Jambi	15.0	Prasetyo et al., (2000)
3	Grassland in Jambi	6.0	Prasetyo et al., (2000)
4	Grassland in Indonesia	10.0	KLH (2003) in PEACE (2007)
5	Plantation in Indonesia	172	KLH (2003) in PEACE (2007)
6	Young palm oil plantation in Nunukan Regency	91	Toemich et al., (1998) in Lusiana et al., (2005)
7	Rubber in Jambi	35.5	Prasetyo et al., (2000)
8	PGHEebunan hasil Earth di Jambi	28.0	Prasetyo et al., (2000)
9	Settlements	0.5	KLH (2003) in PEACE (2007)
10	Rice field in Nunukan Regency	4.8	Lusiana et al., (2005)
11	Rice field in Jambi	7.5	Prasetyo et al., (2000)
12	Rice field in Indonesia	3.5	KLH (2003) in PEACE (2007)
13	Fish pond in Indonesia	1	KLH (2003) in PEACE (2007)
14	Open space in Jambi	0	Prasetyo et al., (2000)
15	Marginal land in Indonesia	37	KLH (2003) in PEACE (2007)
16	*Imperata cylindrica* in Nunukan Regency	4	Lusiana et al., (2005)

17	Upland field in Jambi	7.6	Prasetyo et al., (2000)
18	Cultivated land and settlement in Jambi	3.7	Prasetyo et al., (2000)
19	Mosaic of mixed unproductive lands	35	KLH (2003) in PEACE (2007)
20	Cultivated land and secondary vegetation in Jambi	35.5	Prasetyo et al., (2000)

VI. GREENHOUSE GAS PRODUCTION FROM PALM OIL DEVELOPMENT AND PROCESSING MILL (CPO)

A. Development of Palm Oil Plantation

Figure 6.1. Wet tropical forest after cut, burn and ready to be converted into palm oil plantation

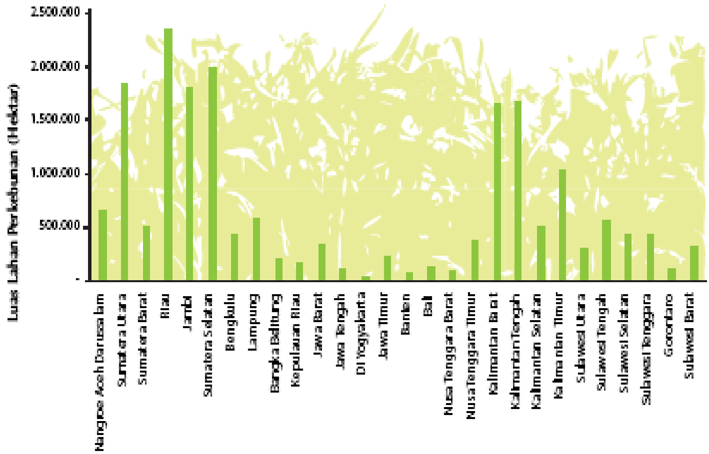
Palm oil (*Elaeis guinensis* Jack) originates from Nigeria, West Africa, although some said that it is originally from Latin America, to be specific from Brazil since there are more palm oil species found within Brazil than Africa (Fauzi et al, 2002). Palm oil is firstly introduced by the Dutch colonial in 1848. At the time there were four palm oil seeds that were brought from Mauritius and Amsterdam and were planted in Bogor Botanical Garden. Commercially, palm oil was cultivated in 1911. The first businessman in palm oil plantation was Adrien Hallet, a Belgian who studied palm oil in Africa.

Growth and production of palm oil are effected by internal and external factors associated with palm oil itself, which can be divided into environmental, genetic and technical agronomy factors of which all are interrelated. To produce maximum palm oil production, these three factors must be in optimum conditions (Fauzi et al, 2002).

Figure 6.2. 1983/1984 Palm oil plant in Tanah Grogot, East Kalimantan

In 2005, Indonesia plantation has reached a total of 18,489,589 ha across 28 provinces (BPS, 2005) where in general they are mostly found within Sumatra and Kalimantan. There are 5 biggest commodities in these plantations: Palm oil (6,594,914 ha), Coconut (3,788,891 ha), Rubber (3,346,427 ha), Cacao (1,320,821 ha) and Coffee (1,255,105 ha). The total area for these commodities during 2004-2007 has increased especially for palm oil plantation that increases to 1 million hectare from 2005 to 2006. During 2006, large palm oil plantations were found in Riau, North Sumatra, South Sumatra, Central Kalimantan and Jambi Provinces.

Within the year 2007, there have been conversions to plantation from forest lands (4,741,194 ha) and transmigration settlements (956,672.81 ha). Based on the available data, it was known that land use change into plantation in Riau province was the highest reaching a figure of 1,611,859.68 ha and followed by Central Kalimantan with 619,868.37 ha. Demands for agriculture and plantation tend to increase, which indirectly caused by the increased demand for production of certain commodities from agricultural and plantation sectors. In plantation sector, there is a promising business and prospects of palm oil plantation. This has caused the expansion of palm oil plantation in several places in Indonesia. In 2006, the production of palm oil reached a total of 16,080,000 tonnes; 3,800,000 tonnes for national consumption and 12,101,000 tonnes for exports. Indonesian palm oil production has contributed about 41 % of world's imports that totalled to 29,178,000 tonnes.



Sumber: BPS, 2005

Figure 6.3. Total plantation area in 2005 (SLI, 2008)

Indonesian government has targeted that by 2010, about 10% of all the national fuel requirements will be supplied through Biofuels; 70% will be based on palm oil or known as biodiesel (SLI, 2008). In order to meet this requirements, there has to be an increased of supply or productivity of palm oil in big amount. Thus the government through the Ministry of Agriculture has targeted expansion and replanting of palm oil under the plantation revitalization program for year 2007-2010 as much as 1,375 million ha (expansion) and 125,000 ha (replanting).

Table 6.1. Total plantation area of 5 (five) biggest commodities in Indonesia in 2006

No	**Province**	**Total Plantation Area (Ha)**				
		Palm Oil	**Coconut**	**Rubber**	**Cacao**	**Coffee**
1	NAD	308,560	112,212	117,711	42,107	107,544
2	North Sumatra	979,541	124,737	456,986	75,925	78,962

3	West Sumatra	315,618	89,313	124,256	36,360	48,093
4	Riau	1,547,942	554,718	369,911	5,586	10,816
5	Jambi	568,751	120,319	433,739	1,417	24,458
6	South Sumatra	630,214	60,792	648,754	3,006	276,864
7	Bengkulu	165,221	8,650	71,334	13,654	120,832
8	Lampung	157,229	147,875	81,466	40,045	164,006
9	Bangka Belitung	133,284	10,266	28,845	177	43
10	Riau Islands	6,933	37,246	30,929	2	156
11	DKI Jakarta	-	-	-	-	-
12	West Java	9,831	191,045	52,336	13,364	21,002
13	Central Java	-	234,339	30,135	7,732	35,525
14	DIY	-	44,024	-	3,868	1,832
15	East Java	-	290,006	25,180	41,658	49,868
16	Banten	14,077	83,407	23,507	5,271	8,474
17	Bali	-	70,389	95	11,312	31,281
18	NTB	-	67,015	-	4,490	12,021
19	NTT	-	160,641	-	40,958	69,009
20	West Kalimantan	492,112	111,468	379,038	8,945	13,937
21	Central Kalimantan	571,874	87,554	255,657	1,419	8,133
22	South Kalimantan	243,451	51,476	129,946	1,676	7,701
23	East Kalimantan	237,765	47,808	58,105	41,414	17,469
24	North Sulawesi	-	269,368	-	10,623	9,579
25	Central	48,431	171,705	3,160	221,812	10,714

	Sulawesi					
26	South Sulawesi	24,490	115,535	19,475	250,233	67,592
27	Southeast Sulawesi	2,966	54,358	-	200,065	10,703
28	Gorontalo	-	62,933	-	9,597	1,642
29	Sulawesi Barat	75,154	67,643	1,209	137,112	26,730
30	Maluku	-	90,310	-	16,574	7,964
31	North Maluku	-	209,792	-	41,198	3,129
32	Papua	29,736	31,005	4,619	20,137	708
33	West Papua	31,734	10,942	34	13,084	8,318
INDONESIA		**6,594,914**	**3,788,891**	**3,346,427**	**1,320,821**	**1,255,105**

Sumber: Departemen Pertanian, 2007

Table 6.2. Balance between demand and supply of palm oil in Indonesia during 1993-2006

Year	(x 1,000 ton)					
	Initial Stock	**Production**	**Import**	**Export**	**Consumption**	**End Stock**
1993	458	3,421	152	1,632	1,790	550
1994	550	4,008	124	1,632	1,985	380
1995	880	4,480	50	1,265	2,115	550
1996	510	4,899	108	1,672	2,528	880
1997	700	5,449	92	2,968	2,841	510
1998	860	5,930	18	1,479	2,832	700
1999	750	6,456	2	3,299	2,895	860
2000	975	7,001	4	4,110	2,927	750
2001	700	8,396	1	4,903	2,857	975
2002	750	9,622	9	6,334	2,933	700
2003	700	10,600	4	6,386	3,165	1,753
2004	1,753	12,380	13	8,996	3,313	1,837
2005	1,837	13,920	22	10,476	3,556	1,747

2006	1,747	16,080	11	12,101	3,800	1,937
Growth %	**10.36 %**	**12.64 %**	**18.29 %**	**16,66 %**	**5.96 %**	**35.244 %**

Source: Adapted from Oil World, 2005

Table 6.3. Balance of demand and supply of world's palm oil in 1993- 2006

Year	**(x 1,000 ton)**					
	Initial Stock	**Production**	**Import**	**Export**	**Consumption**	**End Stock**
1993	2,134	13,806	9,445	9,446	13,259	2,876
1994	2,876	14,137	10,697	10,889	14,6311	2,291
1995	2,282	15,000	10,424	10,285	14,642	2,794
1996	2,900	16,234	10,669	10,735	16,073	3,025
1997	3,140	17,844	12,309	12,374	17,715	3,203
1998	3,245	17,154	11,528	11,417	17,663	2,688
1999	2,892	20,625	13,939	14,172	19,493	3,701
2000	3,701	21,874	15,217	15,217	21,689	4,015
2001	4,063	23,958	17,604	17,793	23,699	4,133
2002	4,133	25,382	19,363	19,438	25,469	4,020
2003	3,970	28,187	21,995	21,910	28,224	3,710
2004	4,020	30,918	23,965	24,001	29,974	4,727
2005	4,727	33,590	26,308	26,545	33,108	4,971
2006	5,213	73,163	29,178	30,000	36,192	5,363

Growth %	7.11 %	7.91 %	9.06 %	9.30 %	8.03 %	4.91 %

Source: Adapted from Oil World, 2005

1. Palm oil plant's biomass

A study was conducted in a palm oil plantation in Riau Province to determine the difference between dry weights of palm oil aged 14 and 19 years old planted on mineral soil (Tjitrosemito and Mawardi, 2000). The total dry weight of palm oil aged 14 years (above and below ground) planted on mineral soils was 706,964 kg where on the trunk itself weight 310,132 kg while for the 19 year old plant, the weight was 672,372 kg where the trunk alone was 355,720 kg. The total dry weight for palm oil planted on peat land aged 10 was 213,477 kg where most of the weight was found on the trunk that is 70,960 kg (Tjitrosemito and Mawardi, 2000).

Table 6.4 Dry weight (DW) of various components of palm oil plant (Tjitrosemito and Mawardi, 2000).

Parts of palm oil plant	Mineral soil				Peat soil	
	14 year		19 year		10 year	
	Average DW per plant (kg)	Average DW (tonnes/ha)	Average DW per plant (kg)	Average DW (tonnes/ha)	Average DW per plant (kg)	Average DW (tonnes/ha)
Trunk	310,132	44,349	355,720	50,868	70,960	10,147
Leaflet	54,801	7,837	46,719	6,681	14,911	2,132
Rachis	52,189	7,463	51,918	7,424	14,940	2,136
Petiole	57,037	8,156	66,785	9,550	19,610	2,804
Inflorescent	1,973	0,282	1,536	0,220	1,538	0,220
Fruit bunch	34,927	4,995	21,653	3,096	17,145	2,452
Left over petiole	93,867	13,423	26,989	3,859	18,010	2,575

Coarse root	87,371	12,494	89,356	12,778	40,531	5,796
Fine root	14,669	2,098	11,696	1,673	15,832	2,264
% root	14.430		15.10		26.40	
Total Dry Weight	706,964	101,096	672,372	96,149	213,477	30,527

Based on measurement carried out by cutting and weighting the above ground biomass of 25 years old palm oil (planting period 1983/1984) planted on mineral soil in Tanah Grogot, East Kalimantan with a total plants of 125 trunks/ha, the resulted total dry weight was 98.91 ton /ha, while biomasses of litters and ground cover amounted to 15.18 tonnes/ha (Table 5.6.)

Table 6.5 Dry weights of various components of 25 years old palm oil plant on mineral soil

Parts of palm oil plant	Mineral soil	
	25 year	
	Average DW per plant (kg)	Average DW (tonnes/ha)
Trunk	674,52	84,32
Pelepah and leaflet	85,95	10,74
Pucuk muda kelapa sawit	1,76	0,22
Fruit bunch	6,24	0,78
Bunga jantan	1,44	0,18
Gulma di batang kelapa sawit	21,36	2,67
Total		98,91

Table 6.6. Dry weights of litters and ground cover found under 25 years old palm oil plants on mineral soil

No.	Biomass Type	Average Dry Weight (kg/m2)	Average Dry Weight (tonnes/ha)
1	Dry litters	0.214	2.14
2	Ground cover	0.747	7.47
3	Grass	0.557	5.57
	Total		15.18

2. Carbon storage in palm oil plant

The percentage of carbon storage on each part of the palm oil plant vary (Table 5.7) between 31.26 % on course litter to 41.55 % on the fruit bunch, while the total carbon storage of the above and below ground is 40.278 tonnes (Tjitrosemito and Mawardi, 2000) or equal to 149.66 ton CO2-eq..

Table 6.7 Carbon storage in a 19 year old palm oil on mineral soil (Tjitrosemito and Mawardi, 2000).

Parts of Palm Oil Plant	Average Dry Weight (tonnes/ha)	% C	Carbon storage (tonnes/ha)
Trunk	50.868	36.32	18.475
Leaflet	6.681	37.42	2.500
Rachis	7.424	35.47	2.633
Petiole	9.550	39.81	3.802
Inflorescent	0.220	36.59	0.080
Fruit bunch	3.096	41.55	1.286
Left over petiole	3.859	36.19	1.397
Coarse root	12.778	39.71	5.074
Fine root	1.673	37.79	0.632
Dead root	0.378	40.62	0.154
Necromass	4.771	38.12	1.819
Undergrowth	1.563	35.74	0.559
Coarse litter	3.149	31.26	0.984
Fine litter	2.567	34.36	0.882
Total			40.278

The amount of carbon storage underground under the palm oils vary in numbers based on the depth of the soil (Table 5.8), where on the depth of 0-5 cm , the amount of carbon is 11.846,4 tonnes/ha and on depth of 20-30 cm is 9.453 tonnes/ha (Tjitrosemito and Mawardi, 2000) or equal to 34,69 ton CO2-eq..

Table 6.8 Carbon storage below ground of 19 year old palm oil (Tjitrosemito and Mawardi, 2000).

Soil depth (cm)	% C-organic	Bulk density (gr/cm3)	Carbon storage (kg/ha)
0-5	1,28	1,851	11.846,4
5-10	1,02	1,851	9.490,1
10-20	0,83	2,106	17.479,8
20-30	0,46	2,055	9.453,0
Total			48.210,3

A study was conducted in Tanah Grogot, East Kalimantan on July 2009 to determine the amount of carbon storage in a 25 years old palm oil plant. The study was done by cutting a 25 years old palm oil that is planted on mineral soil. The results produced a figure of 39.94 tonnes/ha for above ground carbon storage or equal to 146.58 tonnes CO2-eq. The biggest amount was found on the trunk with 29.13 tonnes/ha or equal to 106.91 tonnes CO2-eq (Table 5.9).

Table 6.9 Carbon storage above ground in a 25 year old palm oil on mineral soil in Tanah Grogot, East Kalimantan.

Parts of palm oil	**Average Dry Weight (tonnes/ha)**	**% C**	**Carbon storage (tonnes/ha)**
Trunk	84.32	34.55	29.13
Palm oil fronds and foliage	10.74	36.00	3.87
Young palm oil shoots	0.22	31.15	0.07
Fruit bunch	0.78	45.38	0.35
Male flower	0.18	47.79	0.09
Weeds on trunk	2.67	36.30	0.97
Dry litters	2.14	34.05	0.73
Ground cover	7.47	33.17	2.48
Specific grass	5.57	40.32	2.25
Total			39.94

B. Greenhouse Gas Produced from palm Oil Plantation development and Processing Mills

Greenhouse gas emission produced from palm oil production can be classified into several sources (Brinkman, 2009):

a. Emissions produced during establishment of palm oil plantation and processing of Fresh Fruit Bunch which comprise of :
   a. Emissions related to fuels utilization for internal transportation in planting area and machineries use.
   b. Emissions related to use of fertilizers.
   c. Emissions from fossil fuels utilization in factories and utilization based on the produced products.
   d. Emissions from palm oil mill wastes
   e. Emissions from change in carbon storage during establishment of new plants and within the plant. This includes changes of biomass above and below ground and soil organic materials (including peat).

1. Emissions produced during development of palm oil plantation and processing of Fresh Fruit Bunch (FFB)

a. Emissions related to fuels utilisation for internal transportation in planting area and machineries use.

Fossil fuels are the principal fuels that is use in this activity used for nurseries, maintenance, harvesting, weaning, mill processing and transportation activities on other internal planting (Brinkmann, 2009).

Nikander (2007) estimated an amount of 58-70 litter/ha/year of direct consumption of solar or equal to 3.1 kg CO2-eq/liter or 180-217 kg CO2-eq/ha/year.

Damen and Faaij (2007) assume that all transportation in a planting activity use truck with capacity of 5 tonnes that consumed as much as 1.8 Mj/km of solar with average distance from harvesting site to mill between 10-20 km or equal to 20 tonnes of CO2-eq./TJ solar. This will cause a yearly emission of 94 kg CO2-eq./ha/year.

Wahid et al., (2006) estimates an amount of 4.7 GJ/ha/year in energy consumption by vehicles and machineries. With an assumption of 20 tonnes of CO2-eq./TJ solar, hence within a year, this activity will produce emissions of 94 kg CO2-eq./ha/year.

Based on literature studies (Brinkmann, 2009) it can be concluded that greenhouse gases that are related to fuel (solar) used for local transportation during planting activities and use of machineries vary between 180-225 kg CO2-eq/ha/year.

b. Emissions related to use of fertilizers

The most common fertilizer use in palm oil plantation (Brinkmann, 2009) is nitrogen (Ammonium nitrate, Ammonium sulphate, urea and or Ammonium chloride), Rock phosphate (P2O5), Potassium chloride (K2O) and Kieserite (MgO).

Table 6.10. Commonly used fertilizers in palm oil plantation based on literature studies (Brinkmann, 2009).

Fertilizer Types	Damen and Faaij (2007)	Corley (2003)	Nikande (2007)
Ammonium nitrate (kg N/ha/year)	100	-	96-100
Ammonium sulphate (kg N/ha/year)	-	88.2	-
Rock Phosphate (kg P2O5/ha/year)	45	34.6	28-45
Potassium chloride (kg K2O/ha/year)	205	252	172-20
Kieserite (kg MgO/ha/year)	50	39.2	33-48

Greenhouse Gas emissions that are related to the use of fertilizer within palm oil plantation consist of 2 elements:

1) Emission occurs during production and internal transportation from the main fertilizer during fossil fuel combustion. The emission varies

between fertilizer types, country and means of production.

2) N2O emission during application of nitrogen fertilizer. According to IPCC guidelines (1997), as much as 1.25% of N2O-N from a total of applied N are emitted during the use of fertilizer. Global warming potential of N2) is 301 times greater than that of CO_2.

Nikander (2008) estimated that the gas emissions from fertilizers and pesticides varied between 1086-1500 kg of CO_2-eq/ha/year. While Wijbrans and Van Zutphen (2005) estimated that GHG emissions related to fertilizer use amounts to 1409 kg of CO_2-eq/ha/year. ERIA (2007) estimated CO_2-eq emissions related to fertilizer (mix) use is 17.3 kg CO_2-eq or equal to 19 tonnes of Fresh Fruit Bunch/ha/year of 330 kg of CO_2-eq/ha/year. However, this figure is far less than results from many studies.

Based on literature studies, it can be concluded that GHG emissions that is relate to fertilizer use is between 1500-2000 kg of CO_2–eq/ha/year (Brinkmann, 2009).

c. Emissions from fossil fuels utilization in factories and utilization based on the produced products.

Processing mills required heat which is applied through boilers, generally use fibre and shell materials for fuels. Since these are biomass, then the process of energy generation is CO_2-neutral. Other solid materials that come from mills are empty bunch. These can be use for mulch in garden, landfilled and fuel materials, where each has specific GHG emission. The use of mulch/compost has the potentials to contribute reduce GHG emissions thus can reduce the use of inorganic fertilizers and can improve soil organic materials (Brinkmann, 2009). Based on literature studies, it can be concluded that there are no GHG emissions from the use of fuel materials in mills and application of mills based on the resulting products.

d. Emissions from palm oil mill wastes

Throughout the processes in the mill, liquid wastes will be produced or known as POME. This liquid waste is full of degradable organic

materials (Brinkmann, 2009) or equal to 80,000 mg/l COD and required efforts to reduce it.
Liquid wastes management that is commonly use is pond or lake systems. Unfortunately the natural availability of oxygen in this system is not enough to cater all the aerobic decomposition of organic materials in the wastes (Brinkmann, 2009). As a result, generally the decomposition changed to anaerobic, producing biogas emitted to the atmosphere. Biogas from this waste is primarily composed of CH4 (methane) ranges between 55-65 % which illustrate the substance of GHG source of emission.

Wijbrans and Van Zutphen (2005) has calculated the methane emission from released wastes which is equal to 9 kg/tonnes of FFB (at 0.7 m3 of waste/tonnes FFB), 28 m3 biogas/m3 of wastes (POME) and 65 % of CH4 in the biogas. Other study gave a figure of 28 m3 CH4/m3 of waste which is considered as standard value. Nikander (2008) use the emission range from waste (POME) that is 2500-3800 kg of CO_2-eq/ha/year. Based on literature studies, it can be concluded that GHG emissions from liquid wastes range from 2500-3000 kg of CO_2-eq/ha/year (Brinkmann, 2009).

2. Emissions produced from change in carbon storage during new plants development and within the plants

The emissions resulted from changes in carbon storage during the establishment of new plantation and throughout the operational activities. This include changes of the above and below ground biomass from organic soil materials (including peat).

Development and operationalization of palm oil plantation will produce three different impacts on the stored carbon:

a. Development of plantation will produce changes on every complete forms that are found above and below grounds such as forest and grasses.
b. A palm oil plantation will store carbon through the growth of its palm oil plants.
c. Development and operationalization of palm oil plantation on peatlands required drainage causing oxidation.

a. Emission from above and below ground biomass change

1) Forest
The amount of biomass within wet tropical rain forest vary significantly in respond to their environment, where biomass from lowland forest will be higher than that of mountain forest (Brinkmann, 2009).

Germer and Sauerborn (2007) have conducted reviews on the available data to measure biomass specifically the above ground biomass and obtain a figure of 295±152 tonnes/ha for lowland forest suitable for palm oil plantation. This is similar to the figure given by IPCC for the above ground forest biomass, that is 225 tonnes/ha for Continental Asia and 275 tonnes/ha for Insular Asia. Germer and Sauerborn (2007) has further calculate the below ground biomass and obtain a figure of 47±26 tonnes/ha, hence the total above and below ground biomass of lowland forest that are suitable to be converted into palm oil plantation is 342 ± 178 tonnes/ha.

2) Grassland
Grass biomass is determined by composition and properties of soil, rainfall, fire, wildlife and other factors. IPCC use the value for above ground biomass in tropical savannah using the range between 4.9 tonnes/ha-6.6 tonnes/ha, where Savannah is defined as a vegetation formation with the initial growth of continuous grasses as ground cover. Based on literature study (Brinkmann, 2009) it was known that the above ground grass biomass in a palm oil plantation is 11.2 ± 7.3 tonnes/ha which is greater than cited by IPCC. This is probably due to the difference in soil fertility level and rainfall on the plantation area. Germer and Sauerborn (2007) concluded that the biomass of grasses (above and below ground) on land suitable for palm oil plantation is 26.7 ± 17.4 tonnes/ha.

3) Emissions from litters' decomposition
The development of palm oil plantation required losing forest and ground cover such as grasses. After clearance, if not burned, the remaining biomass will be cleared with the help of termites, insects and micro organism (Brinkmann, 2009). Decomposition releases carbon stored within the biomass to the atmosphere as CO2. A fraction of carbon is releases as methane through activity released by termites. Due to the uncertain impacts of land clearance on the population of rayap and associated released methane,

there are no guidelines on calculating these components in the IPCC methodology. The released CO2 from decomposition is assumed to be a direct function of biomass volume from carbon storage (Brinkmann, 2009). IPCC has predicted that the carbon storage is 50 % from the whole storage. Specifically for *Imperata cylindrica*, a study showed that the carbon storage is 43% (Germer and Sauerborn, 2007).

Decomposition of cleared above and below ground biomass is a long process. After vegetation clearance, the root parts will be rapidly decomposed leaving the big parts to remain. Germer and Sauerborn (2007) stated that there is an uncertain fixed percentage of decomposition. However, they remark that decaying of the whole biomass is estimated to take about 25 years which in turn resulted in the total emission of decomposed biomass of 42±27.3 tonnes of CO2-eq/ha grasses and 627 ± 326.3 tonnes of CO2-eq/ha for forest.

4) Emissions from biomass combustion

Emissions from biomass burning from vegetation clearance depend on the level of burning; such as the proportion of biomass consumed by the fire. IPCC guidelines states that the burning fraction for biomass that originated from forest combustion is 50%, while the guidelines also recommends the actual value for local condition.

Germer and Sauerborn (2007) estimated that as a result of repeated burning, about 40% of carbon stored in the above ground biomass from land clearing that enter the atmosphere through burning process, while the rest are release through decomposition and some stored in the form of charcoal. The above ground biomass of grasses are inflammable, thus the burned fraction is higher than the unburned parts. IPCC recommends in general, values between 80-85% if there are unknown ranges.

Germer and Sauerborn (2007) have also calculated the total emission from the burned above ground biomass and above and below ground biomass decays of 43.5 ± 28.3 tonnes of CO2-eq/ha for grasses and 648.0 ± 337.2 tonnes of CO2-eq/ha for forest.

Based on literature studies (Brinkmann, 2009) it can be concluded that Greenhouse Gases from above and below ground forest biomass clearance is 635 ± 330 tonnes of CO2-eq/ha, while those of grasses ranges between 43 ± 28 tonnes of CO2-eq/ha.

b. Reduced emissions through biomass accumulation on palm oil plantation

Biomass on palm oil plantation can be classified a follows (Brinkmann, 2009):

a. Above ground biomass such as palm oil plant without the roots.
b. Below ground biomass, such as palm oil root
c. Biomass from ground cover vegetation

The amount of carbon stored in the palm oil biomass is a function of growth and ground cover. Values for be above ground biomass of palm oil ranges between 50-100 Mg/ha through to th end of economic planting that is 25 years.

Root biomass of palm oil increases with the increase of above ground biomass, where the maximum volume depends on the soil properties and water availability. Germer and Saurborn (2007) calculates the average root biomass per unit time to 20 ± 5 tonnes/ha.

Biomass of ground cover decreases with increase palm oil plant and reduced sunlight. Germer and Sauerborn (2007) calculate the average total ground cover biomass per unit time is 2.5±1 tonnes/ha with an assumption a rapid development of ground cover with maximum of 10 tonnes/ha and a linier decrease of biomass due to the increased decline sunlight of 1 tonnes/ha on crown cover 5 years after planting. Based on this illustration, Germer and Sauerborn (2007) calculate the total above and below ground biomass of palm oil and provide a figure of 82.5 ± 26 tonnes/ha and carbon fixation of 35.3 ± 11 tonnes/ha within the economical period in palm oil plantation or equal to 129.3 ± 40.3 tonnes of CO2-eq/ha. Henson (2008) has also quantified the carbon storage of palm oil in Malaysia. The average carbon storage of 25 years old palm oil is 2.09 tonnes of carbon/ha/year (or equal to 7.66 tonnes of CO2-eq), where 80 % originated from the average carbon stored in the system (ground cover, litters and 20 % from palm oil production). The total accumulated carbon by palm oil at the end of the cycle is 44 tonnes of C/ha. The average carbon stored in a 30 year planted area is 35.4 tonnes/ha, which is more or less equal to 35.3 tonnes of carbon/ha for the same statement by Germer dan Sauerborn (2007).

Based on literature studies (Brinkman, 2009) it can be concluded that palm oil plant is able to stored as much as 35 tonnes of carbon for a period of 25-30 year, or equal to 130 tonnes of CO2-eq/ha.

c. Emissions through peat decomposition

Under undisturbed condition, the primary peat forest is able to absorb carbon through the accumulation of peat and biomass (Brinkmann, 2009). Drainage and degradation of peat primary forest release carbon primarily through increase peat decomposition. Conversion of peat into palm oil plantation required drainage on depth of 60-80 cm below ground that will trigger peat decomposition.

Delft Hydraulic (2006) has conducted observation on the CO2 emission from drained peatlands in Southeast Asia and produces the following conclusions:

a) Carbon storage in peatlands depends on the type of peat deposits. In SE Asia, almost all lowland peat is derived from forest vegetation and has a high wood content, however the degree of decomposition varies from peatland to peatland and within peatlands. Most studies consider a value in the order of 60 kgC/m3 to be representative for SE Asian peatlands in general.
b) Based on an intensive literature studies on CO2 emissions related to drainage depth on various land uses, generally it is known that a deeper drainage will produce higher emission of CO2/ha. However, particular references on CO2 emission from palm oil plantation gave a figure of about 55 tonnes of CO2-eq/ha/year on drainage with depth of 60 cm (Melling et al., 2005) and 54 tonnes CO2-eq/ha/year on drainage with depth of 80 cm (Muruyama dan Bakar, 1996).
c) In a study, the current and future emissions from drained peatlands were quantified using the latest data on peat extent and depth, present and projected land use and water management practice, decomposition rates and fire emissions. Based on the study, the current CO_2 emissions from decomposition of drained peatland amounts to 632 Mt CO2-eq/year or in average between 355 and 874 Mt/year. In addition, over the periods of 1997-2006 an estimated average of 1400 Mt/year in CO_2 emissions was caused by peatland fires that are also associated with drainage and degradation. The current

total peatland CO_2 emissions are about 2000 Mt CO_2-eq/year or equal to 8% of global fossil fuel burning.

d) Although the study was focussed on emissions from peat decomposition on drained peatlands, fire emissions are also included since fires are often as the result of direct deforestation and drainage. The study concludes that although the current emission of peat combustion is greater than that of peat decomposition, this does not mean that the problem will be solve by extinguishing the fires: fire in peatland is triggered by deforestation and through peat degradation and drying that is related to peat drainage and can be stop in a long term only if the root problems are taken care of. Beside that, stopping the fire without stopping the drainage ill only extend the time of carbon release into the atmosphere.

e) The study also intensively discuss the uncertainty in the assessments methods used including uncertainties related to input data (data on peat and carbon storage), that are related to emissions and trends and projections. These concluded that due to the uncertainties, most of the results are conservative.

Melling et al., (2005) found that soil emission from a primary peat forest is greater than CO2 emission from palm oil plantation. This finding seems to be the opposite from the rest of research results on the conversion of pet forest into palm oil plantation, where the resulting Co2 is higher (Hoojier et al., 2006). This is then facilitated by Alterra (2008) who conduct intensive reviews and concluded that :

- The measurement of CO_2 flux on forest soil such as conducted by Melling et al., (2005) was done on disturb isolated part of the forest and influence by drainage. The high soil emission was thought to be influenced by drainage.
- Hoojier et al., (2006) who conducts a series of measurement of portray big clouds from efflux CO_2 soil shown an uncertainty in the relationship. The increase to obtain regional carbon is hampered through uncertain considerations as cited on their report.

Henson (2008) concluded that there is a big uncertainty on the magnitude of carbon emissions from peat and the relationship with drainage intensity and peat subsidence. Henson used the figure of 7.2 ton carbon/ha/year (based on Wosten et al., 1997) and 9.17 ton carbon/ha/year (Melling et al., 2007). This is equal to 25-30 ton CO2-eq/ha/year.

The conversion of peatland to palm oil plantation required drainage of 60-80 cm below ground supported by peat decomposition and greenhouse gases emission (Brinkmann, 2009). There are many uncertainties of results from various researchers with regard to the real greenhouse gases emission on peatland. Nevertheless, literature studies suggest the realistic figure from a drained peatland is 25-55 tonnes of CO2-eq/ha/year.

d. Greenhouse Gas Emission from Change in Carbon storage

Based on the data and information given above, the net GHG emissions that originated from a change of carbon storage when forest and grassland were converted to palm oil plantation for a period of 25 years, can be calculated (Brinkmann, 2009). Details are shown on the following Table.

Table 6.11. Greenhouse gas emissions (tonnes CO2-eq) from palm oil replacing grasslands and forestlands for 25 years (Brinkmann, 2009)

Source of Emission	Palm oil replacing grassland	Palm oil replacing forest on mineral oil	Palm oil replacing forest on peatland
GHG emissions from original biomass wastes	43 ± 28	635 ± 330	635 ± 330
GHG absorbed by palm oil on mineral soil	-130	-130	-130
GHG absorbed by palm oil on peat soil	0	0	0
Total	-59 to -158	175 - 835	1.175 - 1835

Table 6.12. Impacts of land use change on net emission of CO2 per year and within a period of 25 years (Brinkmann, 2009)

Previous land use	Germer and Sauerborn (2007) (Ton CO2-eq/ha/ year)	Germer and Sauerborn (2007) (Ton CO2-eq/ha/year) for 25 year	Henson (2009) (Ton CO2-eq/ha/ year)	Henson (2009) (Ton CO2-eq/ha/ year) for 25 year
Grassland	- 5,4	-135	-4,3	-37,6

Forest on mineral soil	26,3	657,5	14,5	262,1
Forest on peatland	53	1324,5	44,5	377

e. Resume Greenhouse Gas Emissions produced from palm oil development and processing mill processes

Based on data and information from a research conducted by the researchers, the results is tabulated in more detail in Table 6.13

Table 6.13. Greenhouse gases emissions produced from palm oil plantation development and processing in mills (kg CO2-eq/ha/year)

Source of Greenhouse Gas Emission	**Range**	**Notes**
1.Operational		
a. Fossil fuels use for transport and machineries	180 – 225	
b. Use of fertilizer	1,500 – 2,000	
c. Mill's fuels and utilization based on yield	0	
d. Wastes	2,500 – 4,000	
Total	4,180 – 6,225	
2. Change of stored carbon		
a. Conversion of grassland/forest	1,700 – 45,000	Based on range of 43-635 tonnes CO2-eq
b. Absorbed carbon by palm oil	-5,200	Based on 130 tonnes CO2-eq for the period of 25 year
c. Emission from palm oil on peatland	40,000	Average of 25 – 55 tonnes CO2-eq/ha/year
Total altered stored carbon	3,500 – 90,000	
Total	680 – 96,000	

The above data suggest that conversion of carbon storage in a high biomass to palm oil such as forest or peat will produced the highest GHG as concluded by most researchers.

VII. CONTROVERISES OF MINISTER OF AGRICULTURE REGULATION NO.14 OF 2009

A. Minister of Agriculture Regulation No.14/PL.110/2/2009

Figure 7.1. Palm Oil Plantation on Peatland (dok. SW)

1. Considerations

The government, in this case Ministry of Agriculture on February 16th of 2009 has enacted Minister of Agricultural Regulation No.14/Permentan/PL.110/2/2009 on Guidelines for Peatland Utilization for palm Oil Cultivation. This regulation was issued under the considerations that peatland has significant role in human lives such as through palm oil cultivation. Utilization of peatland for palm oil cultivation can be carried out bearing in mind the land characteristics of peatland to prevent damage on environment. Based on these considerations and so that the development of palm oil cultivation do not degrade environmental functions, there need to be a guideline for utilization of peatland for palm oil cultivation. Apart from that, the birth of this ministerial decree is based on a study by a Research Consortium Team for Ecological Suitability of Peatland for Sustainable Agricultural development Year 2008;

Based on this ministerial regulation, palm oil cultivated is basically done on mineral soil. Due to the limited land available, palm oil cultivation could be done on peat land after fulfilling several criteria to ensure the sustainable function of peatland. These criteria are: (a) as much as possible should be done on communal land or cultivated area, (b) depth of peat is less than 3 (three) meters, (c) the substrate under the peat is not sand quartz nor acid sulphate soil; (d) level of ripeness of peat (sapric – ripe) or hemic (half ripe); and (e) level of eutrophic peat soil fertility

2. Aim and Objectives

The aim of this guideline on palm oil cultivation on peatland is to manage the peatland in a sustainable way considering the ecological function of peatland, with the following objectives:

1. Developing palm oil plantation.
2. Maintaining the function of the peatland.
3. Increasing the production and the income of the palm oil producers.

3. Peatland Criteria

Based on the Ministerial Decree no 14 of 2009, areas of peatland that can be use for palm oil cultivation should fulfil the following criteria:

1. Located on a cultivated area

   The stated area could mean forest areas that have been release and/or other land use areas for palm oil cultivation.

2. Thickness of peat is less than 3 (three) meters

   Areas of peatlands that can be use for palm oil cultivation :

2.1 Should have at least peat thickness of 3 (three) meters ;

2.2 Land proposition with peat thickness less than 3 (three) with a minimum of 70% (seventy percent) of such layer of the total proposed area.

3. The mineral soil layer below the peat substratum will determine the ability of peatland as media for plant growth. This layer should not comprise of sand quartz and acid sulphate soil.

3.1 The sand quartz layer below the peat is a mineral layer that is not mixed with clay soil and composes of true sand thus not suitable for cultivation purposes.

3.2 Acid sulphate soil layer is a tidal land where the soil composed of pirite and suphidic with a content of 2% (two percent) on depth of 50 (fifty) cm below peat soil. Pirite is a mineral material generated from marine sediments rich in iron and suphides in an anaerobe conditions and rich in organic materials.

4. Level of peat ripeness

Level of peat ripeness can be divided into ripe (sapric), half ripe (hemic) and unripe (fibric).

1. Ripe peat (sapric) is peat that has undergone decaying, with unrecognized parent materials, dark brown to black in colour, and if squeezed, the fibre content is less than 15%.
2. Half ripe peat (hemic) that is peat that is halfway decaying, most of the parent materials are recognized, brown in colour, and if squeezed, comprise of 15 – 75% of its fibres.
3. Unripe peat (fibric) is a decomposed peat with recognize parent materials, brown in colour and if squeezed, more than 75% of its fibre are still intact. Palm oil plantation should not be done on unripe peat soil.

5. Soil Fertility

Soil fertility based on Ministry of Agriculture Decree No. 14 of 2009 under eutrophic category, that is peat fertility with adequate macro and micro compounds for palm oil cultivation as the effect of stream water overflow /or marine or sea tides.

6. Land Clearing

Land clearing according to Minister of Agricultural Regulation No. 14 of 2009 should be done without burning and applying good hydrological principles. Water management is specifically done to prevent damage on lands. Intensive and quick drainage of peat cause produce dry peatland and irreversible shrinkage. On such condition, peat is easily burned and difficult to absorb water.

Stages in clearing peatlands are:

1. Establishment of Periphery Drain

a. Establishment of periphery drain as the area boundary; and
b. Periphery drain has a function as ground water level regulator and serve as the main channel. This periphery drain has upper width of ± 4 (four) meter, bottom width of ± 3 (three) m with depth of 2 (two) to 3 (three) meter.

2. Land Clearing

Land clearing on an area with bushes and under brushing comprises of branches less than 2.5 cm in diameter can be done manually or mechanically. Chainsaw should be use if done mechanically:

a. direction of tree felling follows the determine direction and should not be perpendicular to river or roads;

b. height of tree stump that will be log should be based on diameter of the branch as follow:

- Diameter of 10 (ten) cm to 20 (twenty) cm, with height of 40 (forty) cm;
- Diameter of 21 (twenty one) cm to 30 (thirty) cm, with height of 60 (sixty) cm;
- Diameter of 31 (thirty one) cm to 75 (seventy five) cm, with height of 100 (one hundred) cm; or
- Diameter of more than 75 (seventy five) cm, with height of 150 (one hundred and fifty) cm.

c. relatively small branches or twigs should be cut and chopped, while big branch or twigs should be cut into 2 – 3 meter.

d. log, branch and twigs that have been cut should be placed according to trail, that is between two planting rows parallel to planting row.

7. Drainage Regulation

Drainage regulation based on the Minister of Agricultural Regulation No. 14 of 2009 comprise of primary, secondary and tertiary channels with the following size:

Table 7.1. Type of Channel in the Minister of Agricultural Regulation No. 14 of 2009

Type of Drain	Width (m)		Depth (m)
	Upper	Lower	
Primary	– 6.0	– 1.8	– 2.5
Secondary	1.8 – 2.5	0.6 – 0.9	1.2 – 1.8
tertiary	1.0 – 1.2	0.5 – 0.6	0.9 – 1.0

a. Primary Channel

- Primary channel drains water directly to end stream, river or channels; or
- Primary channel can also be a natural creek or a new channel; and
- Build a dike or water gateway on tidal area.

b. Secondary Channel

- Secondary channel drains water to the primary channel.
- Secondary channel catches water from the tertiary channel and also serve as the boundary of the blocks.
- The distance between secondary channels is 400 (four hundreds) meter to 500 (five hundreds) meter with length according to channel condition.

c. Tertiary channel

- Tertiary channel drains water to secondary channel.
- Tertiary channel captures water from the planting area.
- Intervals of tertiary channel depend on the field drainage condition, with maximum of one tertiary channel between two planting rows.

Establishment of water channels are aimed to regulate and maintain ground water level on planting area. On certain places such as the meeting of primary channel with rivers, primary channel and secondary channel, there need to be an automatic water gateway that will open up when the water level on the planting area is higher, and vice versa. Water regulation on drainage channel should follow the depth of ground water level of 60 (sixty) to 80 (eighty) cm, to maintain water availability and preventing fire.

8. Maintenance and conservation

Maintenance and conservation as stated by the Minister of Agriculture Regulation no. 14 of 2009 are done to maintain a certain level of ground water to support growth of plants and preservation of peatland function.

Peat layer should always be maintained below water since peat is easily shrunk. In general, ground water level should be maintained at 60 – 80 cm above ground. Regulation of water depth is also important for inhibiting peat decomposition thus reducing the rate of decrease of peat surface as well as providing anaerobe condition for the development of palm oil roots. To maintain water level and prevent oxidation of pyrite (depth of groundwater does not reach the pyrite layer), drainage channel should be filled with water at required depth

B. Controversies of Minister of Agriculture Regulation no. 14 of 2009

1. Carbon storage in palm oil

Several research results suggest that carbon storage in palm oil (above and below ground) as given by Tjitrosemito and Mawardi (2000) is approximately 40,278 tonnes/ha for palm oil aged 19 and growing on mineral soil or equal to 149,66 tonnes CO2 eq. and based on the research conducted in Tanah Grogot, East Kalimantan, on palm oil aged 25 planted on mineral soil particularly on the surface, the carbon storage is approximately 39,94 tonnes/ha or equal to 146,58 ton CO2 eq./ha.

The amount of carbon stored in the palm oil biomass is a function of growth and ground cover. Values for be above ground biomass of palm oil ranges between 50-100 Mg/ha through to the end of economic planting that is 25 years. Biomass of ground cover increases with increase above ground biomass, and the maximum volume depending on the properties of the soil and water availability. Germer and Saurborn (2007) calculates the average root biomass per unit time to 20 ± 5 tonnes/ha. Biomass of ground cover decreases with increase palm oil plant and reduced sunlight. Germer and Sauerborn (2007) calculate the average total ground cover biomass per unit time is 2.5±1 tonnes/ha with an assumption a rapid development of ground cover with maximum of 10 tonnes/ha and a linier decrease of biomass due to the increased decline sunlight of 1 tonnes/ha on crown cover 5 years after planting. Based on this illustration, Germer and Sauerborn (2007) calculate the total above and below ground biomass of palm oil and provide a figure of 82.5 ± 26 tonnes/ha and carbon fixation of 35.3 ± 11 tonnes/ha within the economical period in palm oil plantation or equal to 129.3 ± 40.3 tonnes of CO2-eq/ha.

Henson (2008) has also quantified the carbon storage of palm oil in Malaysia. The average carbon storage of 25 years old palm oil is 2.09 tonnes of carbon/ha/year (or equal to 7.66 tonnes of CO2-eq), where 80 % originated from the average carbon stored in the system (ground cover, litters and 20 % from palm oil production). The total accumulated carbon by palm oil at the end of the cycle is 44 tonnes of C/ha. The average carbon stored in a 30 year planted area is 35.4 tonnes/ha, which is more or less equal to 35.3 tonnes of carbon/ha for the same statement by Germer dan Sauerborn (2007). Based on literature studies (Brinkman, 2009) it can be concluded that palm oil plant is able to stored as much as 35 tonnes of carbon for a period of 25-30 year, or equal to 130 tonnes of CO2-eq/ha.

2. Greenhouse gas emission

a. Peatland

Under undisturbed condition, the primary peat forest is able to absorb carbon through the accumulation of peat and biomass (Brinkmann, 2009). Drainage and degradation of peat primary forest release carbon primarily through increase peat decomposition. Conversion of peat into palm oil plantation required drainage on depth of 60-80 cm below ground that will trigger peat decomposition.

The conversion of peatland to palm oil plantation required drainage of 60-80 cm below ground supported by peat decomposition and greenhouse gases emission (Brinkmann, 2009). There are many uncertainties of results from various researchers with regard to the real greenhouse gases emission on peatland. Nevertheless, literature studies suggest the realistic figure from a drained peatland is 25-55 tonnes of CO2-eq/ha/year.

Henson (2008) concluded that there is a big uncertainty on the magnitude of carbon emissions from peat and the relationship with drainage intensity and peat subsidence. Henson used the figure of 7.2 tonnes of carbon/ha/year (based on Wosten et al., 1997) and 9.17 tonnes of carbon/ha/year (Melling et al., 2007). This is equal to 25-30 tonnes of CO2-eq/ha/year.

Based on a research conducted by Siregar et al., (2004) on peat forest in Central Kalimantan, it was known that the average above ground carbon storage is 521.703 tonnes/ha atau setara dengan 1,914.65 tonnes of CO2 eq./ha; if added together with below ground stock on depth of 0-30 cm, the total carbon storage is 526.541 tonnes/ha atau setara dengan 1,932.40 tonnes of CO2 eq./ha; on depth 0-100 cm is 588.564 tonnes/ha atau setara dengan 2,160.03 tonnes of CO2 eq./ha on depth 0-300 the carbon storage is 796.401 tonnes/ha atau setara dengan 2,922.79 tonnes of CO2 eq./ha.

On other types of land use such as ex-logging, ex-burned and *Imperata cylindrica* areas, it was known that the carbon storage varied (Siregar et al., 2004). For ex-logging area, the above ground carbon storage is 216.04 tonnes/ha or equal to 792.87 tonnes of CO2 eq/ha, for ex-burned area is 187.725 tonnes/ha or equal to 688.95 tonnes of CO2 eq./ha and for *Imperata cylindrica* area 9.661 tonnes/ha or equal to 35.46 tonnes of CO2 eq./ha. The total above and below ground carbon storage for each land use are also vary. The total above ground carbon storage on depth of 0-30 cm on ex-logging areas are 413.972 tonnes/ha or equal to 1,519.28 tonnes of CO2 eq./ha, on depth 0-100 is 970.359 tonnes/ha or equal to 3,561.22 ton CO2 eq./ha, while on depth of 0-610 cm is 4,263.339 tonnes/ha or equal to 15,646.45 tonnes of CO2 eq./ha.

For ex-burned areas, the total above ground carbon storage on depth 0-30 cm amounts to 411.349 tonnes/ha or equal to 1,509.65 tonnes of CO2 eq./ha, on depth of 0-100 amounts to 1065.056 tonnes/ha or equal to 3,908.75 tonnes of CO2 eq./ha and on depth of 0-610 cm amounts to 4,036.986 tonnes/ha or equal to 14,815.74 tonnes of CO2 eq./ha. The total above ground carbon storage on depth 0-30 cm for *Imperata cylindrica* area is a little bit lower compare to the previous two areas, that is 252.855 tonnes/ha or equal to 927.98 tonnes of CO2 eq./ha, on depth of 0-100 cm totalled to 746.399 tonnes/ha or equal to 2,739.28 tonnes of CO2 eq./ha on depth of 0-580 cm totalled to 3,613.507 tonnes/ha or equal to 13,261.57 tonnes of CO2 eq./ha.

Based on literature studies on carbon storage on peatland with water table more than 25 cm (Verwer et al., 2008) it was known that the above ground carbon storage of wet tropical forest (Lasco, 2002) in average was 323 t C/ha, or equal to 1,185.41 tonnes of CO2 eq./ha, while in Sumatra it is 250 t C/ha (Murdiyarso and Wasrin, 1995) or equal to 917.5 tonnes of CO2 eq./ha. The Net Primary Productivity (NPP) in peat swamp forest is 25 t C/ha/year

(Murdiyarso dan Wasrin, 1995) or equal to 91.75 tonnes of CO2 eq./ha/year while the Net Ecosystem Productivity (NEP) in primary peat swamp forest is 5.32 t C/ha/year (Suzuki, 1999) or equal to 19.19 tonnes of CO2 eq./ha/year.

On peatland (Table 5.7) with table more than 25 cm it was known that the above ground carbon storage of disturbed tropical forest is 181 tonnes/ha (Lasco, 2002) or equal to 664,27 tonnes of CO2 eq./ha, GPP (Gross Primary Productivity) for Central Kalimantan is 34.34 tonnes/ha/year (Hirano et al., 2007) or equal to 126,028 tonnes of CO2 eq./ha dan NEP (Net Ecosystem Productivity) is -4.33 tonnes/ha/year (Hirano et al., 2007) or equal to -15,89 tonnes of CO2 eq./ha/year.

b. Non peat areas

Based on a research on primary dry land in Jambi, it was known that the above ground carbon storage was 252.34 tonnes/ha or equal to 926.09 tonnes of CO2 eq./ha, on secondary dry land was 58.07 tonnes/ha (Prasetyo et al., 2000) or equal to 213.12 tonnes of CO2 eq./ha. The above ground carbon storage from primary dry forest land in Nunukan was 230.1 tonnes/ha or equal to 844.47 tonnes of CO2 eq./ha and secondary dry forest land was 58.0 tonnes/ha (Lusiana et al., 2005) or equal to 212.86 tonnes of CO2 eq./ha.

The carbon storage for shrubs in Nunukan was 19.4 tonnes/ha (Lusiana et al., 2005) or equal to 71.2 or 213.12 tonnes of CO2 eq./ha, while the above ground carbon storage for shrubs in Jambi was 15.0 tonnes/ha or equal to 55.05 or equal 213.12 tonnes of CO2 eq./ha and for grasslands was 6.0 tonnes/ha (Prasetyo et al., 2000) or equal to 22.02 tonnes of CO2 eq./ha.

3. Controversies of Minister of Agriculture Regulation No.14 of 2009

Based on data and facts discussed above, it is known that palm oil plantation planted on mineral soil for 25 years able to absorb 130 tonnes of CO2 eq/ha or if vary, the value will not be more than 180 tonnes of CO2 eq keeping in mind that the above ground carbon storage on palm oil plantation in Tanah Grogot is 39.94 tonnes / ha or equal to 146.58 tonnes of CO2 eq./ha.

The realistic GHG emissions and drained peatland is 25-55 tonnes of CO2-eq/ha/year or equal to 625-1375 tonnes of CO2-eq for 25 years. While for *Imperata cylindrica* area on depth of 0-30 cm the total carbon storage is a little bit lower than the ex-logging and ex-burned areas, that is 252.855 tonnes/ha or equal to 927.98 tonnes of $CO2$ eq./ha.

All of the above data make clear the position of where palm oil should be planted with regard to environmental protection. With the intention to save planet Earth, through preventing the increase of greenhouse gases, it can be concluded that peatlands are not suitable to be converted to palm oil plantation. Such conversion would result in increase the present Greenhouse Gases followed by the establishment of periphery channels as stated in the Minister of Agricultural Regulation No 14 of 2009, "The water channels are aimed to manage ground water level of 60 cm to 80 cm depth, to maintain water availability and preventing fire". Furthermore the guidelines also states that "Maintenance and conservation should be conducted to maintain ground water level on certain depth in order to support the growth of plants and sustainability functions of peatlands". Another important statement of the guidelines is "The peat layer should always be submerged due to shrinkage nature of peat. Therefore, generally, the water level should be maintain at depth of 60 (sixty) cm to 80 (eighty) cm. Regulation of water depth is also important to slow the decomposition of peat hence reducing the decreasing rate of peat surface as well as proving anaerobe zone for the development of palm oil roots. In order to maintain the water level and prevent the oxidation of pyrite layer (water depth does not reach the pyrite layer), therefore the drainage channel should always be filled with water on the required depth". This cause controversies, where planted palm oil on peatland require drainage that will result in increased Greenhouse Gases which is greater that those able to be absorb by the planted palm oil, whereas according to the Minister of Agriculture Regulation No. 14 of 2009, the considerations for issuing such regulation was the utilization of peatlands for palm oil cultivation can be done subject to considering the characteristics of peatlands so as not to produce environmental degradation and also intended for the sustainable function of peatlands.

Another controversial thing is also the consideration of "Results of the 2008 Study of Consortium Team for Ecological Suitability of peatland for the sustainable development of agriculture". Under such guidelines, there are no statements on the results of the study that is use for considerations for conversion of peatland by building channels. If such results were actually use for consideration, then the study should show similar findings with other studies that the conversion of peatland for palm oil plantation would increase Greenhouse gases.

4. Recommendations

In relation to the development of palm oil plantation, Sawit Watch recommends the following bottom lines:

a. Do not expand new plantation in natural forest.
b. Do not expand new plantation in HCVF.
c. Do not use fire during land preparation.
d. Finding alternatives for fossil fuel (diesel).
e. Finding alternatives for urea fertilizers as used by many in Indonesia.
f. Reducing GHG that come from POME using biogas capture or other alternative method.
g. Do not expand new palm oil plantation in peatland.
h. Next palm oil expansion should only be conducted on grassland (*Imperata cylindrica*) on dryland.
i. Providing compensation for the existing plantation on peatland

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ATTACHMENT I

Report on the Biomass Calculation of Palm Oil Plant
East Kalimantan, 31 July - 2 August 2009

I. First day dated 31st of July 2009

The palm oil plantation is owned by Mr.H.S.Nugroho (mobile phone number: 081348580668) which belong to PIR Kuaro, of Kuaro Village (Lingkungan I), Sub-District of Kuaro, Regency of Pasir, East Kalimantan Province, with a total area of 2 ha and planting year of 1983/1984 with a total of 130 trees per ha (planting space of 9 m x 7 m) and seeds are of species Dampi from PPKS Marihat. This location is about 30-40 minutes from the downtown city of Tanah Grogot.

On this location, the cutting activity of palm oil has been conducted since morning time with the use of chainsaw involving many labours. The logged trees are then weight to obtain weight for trunk and tree fronds using weighing scale with capacity of 5-10 kg.

Three (3) palm oil trunks have been scheduled to be logged and all parts will be weight. To ease the calculation and weighing process, the plant was cut into smaller segments. Generally, within a palm oil plant (1) each logged trunk will be divide into several segments or groups to calculate biomass and carbon storage, *i.e* trunk, frond (including the leaves), upper bunch, fruit bunch (including fruit to be) and male fruit.

On the first day, there observed one palm oil plant that has been logged, cut into smaller parts and weight according to parts.

To calculate the water content of each part of the plant that has been log as well as to calculate the total biomass and carbon storage on each part, samples of 100-200 grams were taken, put in a big envelope and labelled for ease for the next process.

Data on the logging process of the first palm oil tree is presented in Table 1

Second day 1st of August

Similar to the first day, the activity for second day is done earlier in the morning on the second trunk that has been logged. After the cutting into segments and weighing of each part, samples of 100-200 grams were taken from each part and put into big envelope and labelled to differentiate.

Data on the logging process of the second palm oil tree is presented in Table 2

After samples are taken, plots are established to calculate the biomass of ground cover from various vegetation types found within the plantation including the intensively and not intensively care. After such plots have been established, the next activity was to cut the ground cover at ground level, separating litters and ground cover, weighing and taking samples for water content, biomass and carbon storage. These samples were placed in big envelope and labelled.

Data on the results of ground cover biomass and litters are provided in Table 3.

After measuring activity on the location of second tree was done, the next activity was the location of third three (last activity). Similar to the prior activities, the third palm oil tree was logged, cut into several segments, and weight for water content, biomass and carbon storage measurement. Samples of 100-200 grams were placed in an envelope and labelled.

Data on the logging process of the third palm oil tree is presented in Table 4.

Several additional information from the owner and local people are given below:

+ During the initial plantation of palm oil in year 1983/1984 the number of stands per ha was 130. However, during the course of time, at 25 years there are three dead stands thus the total became 127.
+ Currently, the soil under the 25 year old plants seemed to harden which according to them was due to the intensive use of inorganic fertilizer (urea). NPK fertilizers were required about 1.5 per stand.
+ One of the means in increasing productivity of Fresh Fruit Bunch (FFB) was through the intensive use of pesticides, which was given once every

year or could be more. The pesticides used was a round-up with dosage of 5 litres for 2 ha of plantation.

+ There was an increase in the production up to 18 years hen become stable and started to decline at 25 years.
+ The FFB production was high that is over 3 tonnes (30-40 tonnes/2ha) on January - April, and 1.5-2 tonnes on September - December and low of about 1 tonne on May - August.
+ Currently, the cost of harvesting FFB is Rp.150.00/ka; cost for transportation to mill is about Rp.100.00/ka and cost of loading and weighing about Rp.12.00/kg, while price of FFB per kg was Rp.800.00 (July 2009), price in February/March 2009 was about Rp.1,360.00/kg.

3. Third day dated 2nd of August 2009

Recapitulation of logging data of the three trees to ensure there are enough data. On the next day, all samples were taken to the Laboratory of Forest and Land Fires to calculate the water contents.

DATA ON PALM OIL BIOMASS OF PASIR REGENCY

LOCATION: PIR KUARO, BLOK IX NO.174
A/N H.S.NUGROHO
KUARO VILLAGE (LINGKUNGAN I), SUB-DISTRICT OF KUARO
PASER REGENCY, PROVINCE OF EAST KALIMANTAN
PLANTING YEAR : 1983/1984
PLANTING SPACE : 9 X 7 (PER HA 125-130 BATANG)
ORIGIN OF SEED : PPKS/MARIHAT

Table 1. Data of First Logged Palm Oil

No.	Distance between cuts (cm)	Diameter (cm)	Wet Weight (kg)	Dry Weight (kg)	% Carbon	Carbon storage (kg)
Trunk						
1	40	95	163	92.39	39.51	36.50
2	100	80	298	123.10	36.49	44.92
3	110	52	222	128.76	38.82	78.77
4	100	49	157	71.12	37.62	26.76
5	103	42	120	69.43	38.24	26.55
6	106	42	115	66.11	40.33	26.66
7	98	41	105	54.95	36.82	20.23
8	102	35	79	28.45	39.15	11.14
9	99	35	78	39.99	39.50	15.79
10	107	33	85	47.72	39.48	18.84
11	100	29	80	54.49	35.85	19.53
12	50	27	48	19.2	41.58	7.98
Total				794.71		333.67
13	Fronds and foliage		247	98.8	36.16	35.73

14	Young shoots	5	1.45	31.15	0.45
15	Fruit	20	10.8	41.85	4.52
16	Male flower	2	1.69	47.79	0.81
17	Weed on trunk	110	44	36.30	15.97
Total		156.74		57.48	
Total		1.934	951.45		391.15

Table 2. Data of second logged palm oil

No.	Distance between cuts (cm)	Diameter (cm)	Wet Weight (kg)	Dry Weight (kg)	% Carbon	Carbon Content (kg)
Trunk						
1	55	72	80	23.2	49.80	11.55
2	95	63	228	27.36	40.13	10.98
3	93	53	181	49.18	39.59	19.47
4	100	46	145	68.15	39.06	26.62
5	101	43	130	75.71	37.15	28.13
6	102	41	125	48.84	40.33	19.69
7	100	40	115	50.51	37.17	18.77
8	100	40	110	48.4	40.32	19.51
9	100	38	91	48.12	35.59	17.13
10	105	35	80	26.6	36.85	9.80
11	90	34	70	40.31	51.43	20.73
12	90	20	21	8.40	38.48	3.23

Total		514.78		205.61	
13	Fronds and foliage	194	50.44	35.92	18.12
14	Young shoot	4	1.64	31.15	0.51
15	Fruit	7	4.2	41.85	1.76
16	Male flower	1	0.83	47.79	0.39
17	Weed on trunk			-	
Total		57.11		20.78	
Total		571.89		226.39	

Table 3. Data of third logged palm oil

No.	Distance between cuts (cm)	Diameter (cm)	Wet Weight (kg)	Dry Weight (kg)	% Carbon	Carbon Content (kg)
Stem						
1	45	65	90	45.13	50.48	22.78
2	105	60	215	112.83	37.54	42.36
3	102	47	175	101.5	37.55	38.11
4	105	45	135	75.72	36.54	27.67
5	110	40	125	71.25	38.7	27.57
6	100	39	120	58.45	35.85	20.95
7	100	39	110	61.03	41.15	25.11
8	100	39	105	59.53	39.56	23.55

9	100	39	103	48.41	37.4	18.17
10	100	36	90	37.8	40.31	15.24
11	105	34	88	34.42	38.65	13.30
12	90	30	20	8.0	40.32	3.23
Total		714.07			278.04	
13	Fronds and foliage	263	108.62		35.92	39.02
14	Young shoot	5	2.06		31.15	0.64
15	Fruit	7	3.71		52.44	1.94
16	Male flower	2	1.68		47.79	0.80
17	Weed on trunk	20	12		36.30	4.36
Total		128.07			46.76	
Total		842.14			324.8	

Table 4. Potentials of litters and upper parts of ground cover within a 25 years intensive care palm oil

No.	Source of biomass	Potential (kg/m2)	Dry weight (kg/m2)	% Carbon	Carbon storage (kg/m2)	Notes

1	Dry litters	0.243	0.214	34.05	0.073	Intensive care
2	Ground cover	1.204	0.747	33.17	0.248	Including foliage and trunk (Average height 0.5-1.5 m)
3	Specific grass	0.605	0.557	40.32	0.225	Intensive care
Total	2.052		1.518		0.546	
Average	0.684		0.506		0.182	

Table 5. Surface carbon storage, litters and ground cover of an intensive care 25 year old palm oil

No.	Source of biomass	Average total of dry weight (tonnes/ha)	% Carbon	Carbon storage (tonnes/ha)
1.	Palm oil trunk	84.32	34.55	29.13
2.	Fronds and foliage of palm oil	10.74	36.00	3.87
3.	Palm oil young shoot	0.22	31.15	0.07
4.	fruit	0.78	45.38	0.35
5.	Male flower	0.18	47.79	0.09
6.	Weed on trunk	2.67	36.30	0.97
7.	Dry litter	2.14	34.05	0.73

8	Ground cover	7.47	33.17	2.48
9.	Specific grass	5.57	40.32	2.25
Total		39.94		

ATTACHMENT II

Table 1. Estimation of above ground biomass per ha of peat forest in Central Kalimantan(Siregar et al., 2004).

No.	Component	Plot 1 (tonnes/ha)	Plot 2 (tonnes/ha)	Plot 3 (tonnes/ha)	Average (tonnes/ha)
1	Stand biomass	904.416	358.517	485.528	582.820
2	Root biomass	122.848	163.381	163.381	179.922
3	Ground cover biomass	34.575	33.548	33.548	45.340
	Total	1.061.839	679.949	682.457	808.082

Table 2. Estimation of below ground biomass per ha of peat forest in Central Kalimantan (Siregar et al., 2004).

No.	Depth (cm)	Plot 1 (tonnes/ha)	Plot 2 (tonnes/ha)	Plot 3 (tonnes/ha)	Average (tonnes/ha)
1	0-30	6.756	11.712	6.672	8.380
2	0-100	108.48	135.12	105.74	116.447
3	0-300	534.36	534.36	534.36	534.360

Table 3. Total biomass of peat forests in Central Kalimantan (Siregar et al., 2004)

No.	Component	Plot 1 (tonnes/ha)	Plot 2 (tonnes/ha)	Plot 3 (tonnes/ha)	Average (tonnes/ha)
1	Above ground biomass	1,061.839	679.949	682.457	808.082
2	Soil	6.756	11.712	6.672	8.380
	Total (0-30 cm)	1,068.415	691.661	689.129	816.462
3	Soil	108.48	135.12	105.74	116.447
	Total (0-100 cm)	1,170.319	815.069	788.197	924.529
4	Soil	534.36	534.36	534.36	534.36
	Total (0-300 cm)	1,596.199	1,214.309	1,216.817	1,342.442

Table 4. Total carbon storage of peat forest in Central Kalimantan (Siregar et al., 2004).

No.	Component	Plot 1 (tonnes/ha)	Plot 2 (tonnes/ha)	Plot 3 (tonnes/ha)	Average (tonnes/ha)
1	Above ground biomass	681,791	413,191	470,128	521,703
2	Soil	3,901	6,764	3,85	4,838
	Total (0-30 cm)	685,692	419,955	473,978	526,541
3	Soil	62,133	77,866	60,585	66,861
	Total (0-100 cm)	743,924	491,057	530,713	588,564
4	Soil	274,698	274,698	274,698	274,698
	Total (0-300 cm)	956,489	687,889	744,826	796,401

Table 5. Depth of peat in the study area in Central Kalimantan (Siregar et al., 2004).

No.	Type of Land Use	Above ground carbon storage (tonnes/ha)	Below ground carbon storage		Total carbon storage (tonnes/ha)
			Peat depth (cm)	Carbon storage (tonnes/ha)	
1	Ex-logging areas	216.04	0-30	197.392	413.972
			0-100	754.393	970.359
			0-350	2747.515	2963.565
			0-420	2979.354	3195.393
			0-500	3743.422	3959.462
			0-610	4407.299	4263.339
2	Ex-burn areas	187.725	0-30	223.6237	411.349
			0-100	877.331	1065.056
			0-350	2663.98	2851.785
			0-420	3082.75	3270.475
			0-500	3240.627	3428.352
			0-610	3849.261	4036.986
3	*Imperata cylindrica*	9.661	0-30	241.1935	252.855
			0-100	736.7379	746.399
			0-350	2607.478	2617.139
			0-420	3270.751	3280.412

			0-580	3603.846	3613.507

Plot	Sub-plot	Depth (cm)
I	1	334
	2	327
	3	338
	4	320
	5	330
Total		1,649
Average		329.8
II	1	308
	2	337
	3	316
	4	330
	5	313
Total		1,604
Average		320.8
III	1	370
	2	380
	3	370
	4	374
	5	384
Total		1,878
Average		375.6

Table 6. Carbon storage on ex-logging, ex-burning and *Imperata cylindrica* areas in Central Kalimantan (Siregar et al., 2004).

Table 7. Carbon budgets (without insertion of below ground biomass) from undisturbed and disturbed peat forests and palm oil plantations on several locations in Southeast Asia based on literature studies (Verwer et al, 2008).

Peat with water table > 25 cm	**Total**	**Unit**	**Source**	**Location**
Above ground carbon storage	323	t C/ha	Lasco (2002)	Average wet tropical rain forest
	250	t C/ha	Murdiyarso and Wasrin (1995)	Sumatra
CO2 emissions from soil and root respiration	9,55	t C/ha/year	Jauhiainen et al (2005)	Central Kalimantan
	10,64	t C/ha/year	Muruyama and Bakar (1996)	Western part of Johor
	9.28	t C/ha/year	Jauhiainen et al (2005)	Recovering forest
NPP (Net Primary Productivity)	25	t C/ha/year	Murdiyarso and Wasrin (1995)	Peat swamp forest
NEP (Net Ecosystem Productivity)	5,32	t C/ha/year	Suzuki (1999)	Peat swamp primary forest
	5,22	t C/ha/year	Suzuki (1999)	Peat swamp secondary forest
	1,62	t C/ha/year	Henson (2005)	Undisturbed peat swamp forest
Peat with water table < 20 cm	**Total**	**Unit**	**Source**	**Location**
Above ground carbon storage	181	t C/ha	Lasco (2002)	Average for disturbed tropical forest

CO2 emissions from soil and root respiration	21	t C/ha/year	Melling et al (2005)	Sarawak
GPP (Gross Primary Productivity)	34,34	t C/ha/year.	Hirano et al (2007)	Central Kalimantan
NEP (Net Ecosystem Productivity)	-4,33	t C/ha/year.	Hirano et al (2007)	Central Kalimantan

Table 8. Carbon storage above ground on forest and non-forest areas

No.	Land cover	Carbon (T C/ha)	Source
	Forest		
1	Primary dryland forest in Jambi	252.34	Prasetyo et al., (2000)
2	Secondary dryland forest in Jambi	58.07	Prasetyo et al., (2000)
3	Primary dryland forest in Nunukan Regency	230.1	Lusiana et al., (2005)
4	Secondary dryland forest in Nunukan Regency	58.0	Lusiana et al., (2005)
5	Primary forest in Sumatera	300	Lasco (2002) in Lusiana et al., (2005)
6	Primary mangrove forest in Nunukan Regency	176.8	Lusiana et al., (2005)
7	Plantation forest	124.4	Handayani (2003)
	Non forest		
1	Shrubs in Nunukan Regency	19.4	Lusiana et al., (2005)
2	Shrubs in Jambi	15.0	Prasetyo et al., (2000)
3	Grassland in Jambi	6.0	Prasetyo et al., (2000)
4	Grassland in Indonesia	10.0	KLH (2003) in PEACE (2007)

5	Plantation in Indonesia	172	KLH (2003) in PEACE (2007)
6	Young palm oil plantation in Nunukan Regency	91	Toemich et al., (1998) in Lusiana et al., (2005)
7	Rubber in Jambi	35.5	Prasetyo et al., (2000)
8	Plantation of resources in Jambi	28.0	Prasetyo et al., (2000)
9	Settlements	0.5	KLH (2003) in PEACE (2007)
10	Rice field in Nunukan Regency	4.8	Lusiana et al., (2005)
11	Rice field in Jambi	7.5	Prasetyo et al., (2000)
12	Rice field in Indonesia	3.5	KLH (2003) in PEACE (2007)
13	Fish pond in Indonesia	1	KLH (2003) in PEACE (2007)
14	Open space in Jambi	0	Prasetyo et al., (2000)
15	Marginal land in Indonesia	37	KLH (2003) in PEACE (2007)
16	*Imperata cylindrica* in Nunukan Regency	4	Lusiana et al., (2005)
17	Upland field in Jambi	7.6	Prasetyo et al., (2000)
18	Cultivated land and settlement in Jambi	3.7	Prasetyo et al., (2000)
19	Mosaic of mixed unproductive lands	35	KLH (2003) in PEACE (2007)
20	Cultivated land and secondary vegetation in Jambi	35.5	Prasetyo et al., (2000)

Table 9. Dry weight of various components of palm oil plant (Tjitrosemito dan Mawardi, 2000).

Part o f palm oil plant	Average Dry Weight (tonnes/ha)	% C	Carbon Content (tonnes/ha)
Trunk	50.868	36.32	18.475
Leaflet	6.681	37.42	2.500
Rachis	7.424	35.47	2.633
Petiole	9.550	39.81	3.802
Inflorescent	0.220	36.59	0.080
Fruit bunch	3.096	41.55	1.286
Left over petiole	3.859	36.19	1.397
Coarse root	12.778	39.71	5.074
Fine root	1.673	37.79	0.632
Dead root	0.378	40.62	0.154
Necromass	4.771	38.12	1.819
Undergrowth	1.563	35.74	0.559
Coarse litter	3.149	31.26	0.984
Fine litter	2.567	34.36	0.882
Total			40.278

Table 10. Carbon storage in Palm Oil Plant
(Tjitrosemito and Mawardi, 2000).

Parts of palm oil plant	Mineral soil				Peat soil	
	14 year		19 year		10 year	
	Average Dry Weight per plant (kg)	Average Dry Weight (tonnes/ha)	Average Dry Weight per plant (kg)	Average Dry Weight (tonnes/ha)	Average Dry Weight per plant (kg)	Average Dry Weight (tonnes/ha)
Trunk	310.132	44.349	355.720	50.868	70.960	10.147
Leaflet	54.801	7.837	46.719	6.681	14.911	2.132
Rachis	52.189	7.463	51.918	7.424	14.940	2.136
Petiole	57.037	8.156	66.785	9.550	19.610	2.804
Inflorescent	1.973	0.282	1.536	0.220	1.538	0.220
Fruit bunch	34.927	4.995	21.653	3.096	17.145	2.452
Left over petiole	93.867	13.423	26.989	3.859	18.010	2.575
Coarse root	87.371	12.494	89.356	12.778	40.531	5.796
Fine root	14.669	2.098	11.696	1.673	15.832	2.264
% root	14.430		15.10		26.40	
Total Dry Weight	706.964	101.096	672.372	96.149	213.477	30.527

Table 11. Soil carbon content under 19 years old palm oil plants (Tjitrosemito and Mawardi, 2000).

Soil depth (cm)	% C-organic	Bulk density (gr/cm3)	Carbon content (kg/ha)
0-5	1,28	1,851	11.846,4
5-10	1,02	1,851	9.490,1
10-20	0,83	2,106	17.479,8
20-30	0,46	2,055	9.453,0
Total			48.210,3

Table 12. Above ground biomasses of various land use types on peat swamp forest in Central Kalimantan (Siregar et al., 2004)

No.	Components	Ex-logging areas (tonnes/ha)	Ex-fire areas (tonnes/ha)	*Imperata cylindrica* (tonnes/ha)
1	Stand biomass	288,023	227,115	-
2	Root biomass	46,818	38,372	-
3	Ground cover biomass	41,428	63,534	20,104
	Total Biomass	376,269	329,020	20,104

Table 13. Estimation of below ground biomass on various land uses on peat swamp forest in Central Kalimantan (Siregar et al., 2004)

No.	Land use type	Depth(cm)	Biomass (tonnes/ha)
1	Ex-logging areas	0-30	343.308
		0-100	1451.563
		0-350	4765.109
		0-420	5181.660
		0-500	6488.466
		0-610	7649.141
2	Ex-fire areas	0-30	388.953

		0-100	1394.928
		0-350	4673.989
		0-420	5388.188
		0-500	6059.906
		0-610	6688.905
3	*Imperata cylindrica*	0-30	427.321
		0-100	1359.470
		0-350	4370.505
		0-420	5707.725
		0-500	6323.578

Table 14. Biomass potentials of *Imperata cylindrica* in Central Kalimantan (Siregar et al., 2004)

Depth (cm)	Biomass (tonnes/ha)			Bulk density (g/cm3)
	Sub-2	Sub-4	Sub-5	
0-10	90.253	101.05	155.11	0.1044-0.1742
10-20	96.33	86.03	158.07	0.0982-0.1853
20-30	113.12	106.39	165.63	0.1442-0.1678
30-40	92.74	95.95	139.07	0.1005-0.1432
40-50	95.49	98.86	145.25	0.1053-0.1306

50-60	112.17	59.54	135.13	0.0732-0.1505
60-70	100.02	116.82	168.42	0.0973-0.1334
70-80	116.13	127.95	162.39	0.1371-0.1943
80-90	133.28	154.80	154.12	0.1042-0.1466
90-100	129.67	127.44	117.07	0.1186-0.1422

Table 15. Carbon storage below ground of *Imperate cylindrica* in Central Kalimantan

Depth (cm)	% Carbon		
	Sub-2	Sub-4	Sub-5
0-10	57.42	57.37	57.47
10-20	57.71	57.87	57.71
20-30	57.50	57.67	57.68
30-40	57.72	57.66	57.71
40-50	57.65	57.70	57.79
50-60	57.65	57.76	57.63
60-70	57.71	57.69	57.77
70-80	57.84	57.71	57.71
80-90	57.76	57.79	57.80
90-100	57.76	57.89	57.86

[i] ANNUAL REPORT OF THE UNITED NATIONS HIGH COMMISSIONER FOR HUMAN RIGHTS AND REPORTS OF THE OFFICE OF THE HIGH COMMISSIONER AND THE SECRETARY-GENERAL
Report of the Office of the United Nations High Commissioner for Human Rights on the relationship between climate change and human rights*
[ii] See Millennium Ecosystems Assessment 2005, *Ecosystems and Human Well-being*, Synthesis, pp. 67 and 79.
[iii] A joint seminar on human rights and the environment organized by OHCHR and UNEP in 2002 also documented a growing recognition of the connection between human rights, environmental protection and sustainable development (see E/CN.4/2002/WP.7).
[iv] ILO Convention No. 169 (1989) concerning Indigenous and Tribal Peoples in Independent Countries provides for special protection of the environment of the areas which indigenous peoples occupy or otherwise use. At the regional level, the African Charter on Human and Peoples' Rights and the San Salvador Protocol to the American Convention on Human Rights recognize the right to live in a healthy or satismill environment. Moreover, many national constitutions refer to a right to an environment of a certain quality.
[v] Convention on the Rights of the Child (CRC), art. 24, para. 2 (c).
[vi] Human Rights Committee, general comments No. 6 (1982) on art. 6 (Right to life), para. 1,
and No. 14 (1984) on art. 6 (Right to life), para. 1.
[vii] Human Rights Committee, general comment No. 6, para. 5. Likewise, the Committee has asked States to provide data on pregnancy and childbirth-related deaths and gender-disaggregated data on infant mortality rates when reporting on the status of implementation of the right to life (general comment No. 28 (2000) on art. 3 (The equality of rights between men and women), para. 10).
[viii] CRC, art. 6, para. 2.
[ix] Committee on the Rights of the Child, general comment No. 7 (2006) on implementing rights in early childhood, para. 10.
[x] IPCC AR4 Working Group II (WGII) Report, p. 393.
[xi] United Nations Development Programme (UNDP), Human Development Report 2007/2008, *Fighting climate change: Human solidarity in a divided world*, p. 8.

[xii] IPCC AR4 Working Group II Report, p. 317.
[xiii] Inter-Agency Standing Committee, *Protecting Persons Affected by Natural Disasters – IASC Operational Guidelines on Human Rights and Natural Disasters*, Brooking-Bern Project on Internal Displacement, 2006.
[xiv] International Covenant on Economic, Social and Cultural Rights (ICESCR), art. 11; CRC,
art. 24 (c); Convention on the Rights of Persons with Disabilities (CRPD), art. 25 (f) and art. 28, para. 1; Convention on the Elimination of All Forms of Discrimination against Women (CEDAW), art. 14, para. 2 (h); International Convention on the Elimination of All Forms of Racial Discrimination (ICERD), art. 5 (e).
[xv] CESCR general comment No. 12 (1999) on the right to adequate food (art. 11), para. 6.
[xvi] IPCC AR4 Synthesis Report, p. 48.
[xvii] UNDP Human Development Report 2006, *Beyond scarcity: Power*, *poverty and the global*
water crisis.
[xviii] IPCC AR4 WGII Report, p. 275.
[xix] IPCC AR4 WGII, p. 359. United Nations Millennium Project 2005, *Halving Hunger: It Can Be Done*, Task Force on Hunger, p. 66. Furthermore, according to the Human Rights Council Special Rapporteur on the right to food, "half of the world's hungry people … depend for their survival on lands which are inherently poor and which may be becoming less fertile and less productive as a result of the impacts of repeated droughts, climate change and unsustainable land use" (A/HRC/7/5, para. 51).
[xx] See e.g. A/HRC/7/5, para. 51; A/HRC/7/5/Add.2, paras. 11 and 15.
[xxi] See e.g. CESCR general comment No. 12 (1999) on the right to adequate food (art. 11), para. 28.
[xxii] CESCR general comment No. 15 (2002) on the right to water (arts. 11 and 12), para. 2. While not explicitly mentioned in ICESCR, the right is seen to be implicit in arts. 11 (adequate standard of living) and 12 (heath). General comment No. 15 provides further guidance on the normative contents of the right to water and related obligations of States.
[xxiii] See CEDAW, art. 14, para. 2 (h); CRPD, art. 28, para. 2 (a); CRC, art. 24, para. 2 (c).
[xxiv] IPCC AR4 Synthesis Report, pp. 48-49.

[xxv] Millennium Ecosystems Assessment 2005, *Ecosystems and Human Well-being*, Synthesis, p. 52.
[xxvi] According to the UNDP Human Development Report 2006, the root causes of the current water crisis lie in poor water management, poverty and inequality, rather than in an absolute shortage of physical supply.
[xxvii] IPCC AR4 WGII Report, p. 191. UNDP Human Development Report 2006.
[xxviii] CEDAW, arts. 12 and 14, para. 2 (b); ICERD, art. 5 (e) (iv); CRC, art. 24; CRPD, arts. 16, para. 4, 22, para. 2, and 25; International Convention on the Protection of the Rights of All Migrant Workers and Members of Their Families (ICRMW), arts. 43, para. 1 (e), 45, para. 1 (c), and 70. See also ICESCR arts. 7 (b) and 10.
[xxix] CESCR general comment No. 12, para. 8.
[xxx] See CESCR general comment No. 12, CEDAW general recommendation No. 24 (1999) on art. 12 of the Convention (women and health); CRC general comment No. 4 (2003) on Adolescent health and development in the context of the Convention on the Rights of the Child.
[xxxi] IPCC AR4 Synthesis, p. 48.
[xxxii] Uncertainty remains about the potential impact of climate change on malaria at local and global scales because of a lack of data and the interplay of other contributing non-climatic factors such as socio-economic development, immunity and drug resistance (see IPCC WGII Report, p. 404).
[xxxiii] *Modified from "Poverty and Environment," a background paper to the Environment Strategy 2000/World Bank.*
[xxxiv] A/62/214, para. 102.
[xxxv] IPCC AR4 WGII Report, p. 12.
[xxxvi] ICESCR, art. 11. See also Universal Declaration of Human Rights, art. 25, para. 1; ICERD, art. 5 (e) (iii); CEDAW, art. 14, para. 2; CRC, art. 27, para. 3; ICRMW, art. 43, para. 1 (d); CRPD, arts. 9, para. 1 (a), and 28, paras. 1 and 2 (d).
[xxxvii] CESCR general comment No. 12, para. 6.
[xxxviii] See CESCR general comment No. 7 (1997) on the right to adequate housing (art. 11 (1) of the Covenant): Forced evictions.
[xxxix] CESCR general comment No. 12, para. 8.
[xl] IPCC AR4 WGII Report, p. 333.
[xli] IPCC AR4 WGII Report, p. 672.
[xlii] A/63/275, paras. 31-38.

[xliii] UNDP Human Development Report 2007/2008, *Fighting climate change: Human solidarity in a divided world*, p. 9.
[xliv] In this regard the Guiding Principles on Internal Displacement (E/CN.4/1998/53/Add.2, annex) provide that "at the minimum, regardless of the circumstances, and without discrimination, competent authorities shall provide internally displaced persons with and ensure safe access to: … basic shelter and housing" (principle 18).
[xlv] The right to self-determination is enshrined in Articles 1 and 55 of the Charter of the United Nations and also contained in the Declaration on the Right to Development, art. 1, para. 2, and the United Nations Declaration on the Rights of Indigenous Peoples, arts. 3 and 4.
[xlvi] Human Rights Committee, general comment No. 12 (1984) on art. 1 (Right to self-determination), para. 6. See also Committee on the Elimination of Racial Discrimination (CERD), general recommendation 21 (1996) on the right to self-determination.
[xlvii] See e.g. IPCC AR4 WGII Report, p. 374.
[xlviii] National communications, submitted according to arts. 4 and 12 of UNFCCC, make frequent references to the human impacts of climate change, but generally do so in an aggregate and general manner, mentioning for example that people living in poverty are particularly vulnerable.
[xlix] IPCC AR4 WGII, p. 398. See also submission by the United Nations Development Fund for Women available at: http://www2.ohchr.org/english/issues/climatechange/index.htm.
[l] E. Neumayer and T. Plümper, *The Gendered Nature of Natural Disasters: The Impact of Catastrophic Events on the Gender Gap in Life Expectancy, 1981-2002*, available at http://ssrn.com/abstract=874965. As the authors conclude, based on the study of disasters in 141 countries, "[a] systematic effect on the gender gap in life expectancy is only plausible if natural disasters exacerbate previously existing patterns of discrimination that render females more vulnerable to the fatal impact of disasters" (p. 27).
[li] Y. Lambrou and R. Laub, "Gender perspectives on the conventions on biodiversity, climate change and desertification", *Food and Agriculture Organization of the United Nations (FAO), Gender and Population Division*, pp. 7-8.

[lii] See e.g. IPCC AR4 WGII Report, p. 398; International Strategy for Disaster Reduction, *Gender Perspectives: Integrating Disaster Risk Reduction into Climate Change Adaptation. Good Practices and Lessons Learned*, UN/ISDR 2008.
[liii] UNFCCC, *Climate Change: Impacts, Vulnerabilities and Adaptation in Developing Countries*, 2007, p. 16.
[liv] UNICEF Innocenti Research Centre, *Climate Change and Children: A Human Security Challenge*, New York and Florence, 2008; UNICEF UK, *Our Climate, Our Children, Our Responsibility: The Implications of Climate Change for the World's Children*, London, 2008.
[lv] World Bank, *Global Monitoring Report 2008 - MDGs and the Environment: Agenda for Inclusive and Sustainable Development*, p. 211.
[lvi] UNICEF UK (see footnote 69 above), p. 29.
[lvii] For example, UNEP and UNICEF have developed an environmental resource pack for child-friendly schools designed to empower children (see footnote 69 above, UNICEF Innocenti Research Centre, p. 28).
[lviii] See e.g. CRC, general comment No. 4 (2003) on adolescent health and development in the context of the Convention on the Rights of the Child.
[lix] M. Macchi and others, *Indigenous and Traditional Peoples and Climate Change*, International Union for Conservation of Nature, 2008.
[lx] See e.g. report of the Special Rapporteur on the situation of human rights and fundamental freedoms of indigenous peoples, A/HRC/4/32, para. 49.
[lxi] In April 2008, the Permanent Forum for Indigenous Issues stated that climate change "is an urgent and immediate threat to human rights" (E/C.19/2008/13, para. 23).
[lxii] E/C.19/2008/13, para. 4. The Permanent Forum also recommended that a mechanism be put in place for the participation of indigenous peoples in climate change negotiations under UNFCCC (ibid., para. 30).
[lxiii] IPCC AR4 WGII Report, p. 865 (citing Robinson and Herbert, 2001).
[lxiv] Key provisions include the right to effective mechanisms for prevention of, and redress for,
actions which have the aim or effect of dispossessing them of their lands, territories or resources (art. 8); the principle of free, prior and informed consent (art. 19), the right to the conservation and protection of the environment and indigenous lands and territories (art. 29), the right to

maintain, control, protect and develop their cultural heritage and traditional knowledge and cultural expressions (art. 31).

[lxv] See the provisions on cultural rights in ICCPR, art. 27, and ICESCR, art. 15.

[lxvi] Available at: http://inuitcircumpolar.com/files/uploads/icc-files/FINALPetitionICC.pdf.

[lxvii] More recent studies refer to estimates for the same period of 200 million (Stern Review on the Economics of Climate Change, 2006, available at http://www.hm-treasury.gov.uk/sternreview_index.htm) and 250 million (*Human tide: the real migration crisis*, Christian Aid 2007). See also IPCC AR4 WGII Report, p. 365 and the Norwegian Refugee Council, *Future floods of refugees: A comment on climate change, conflict and forced migration*, 2008.

[lxviii] See e.g. contributions to *Forced Migration Review, vol. 1, No. 31*, October 2008.

[lxix] Adapted from typology proposed by the Representative of the Secretary-General on human rights of internally displaced persons and also used in the working paper submitted by the IASC informal group on migration/displacement and climate change, "Climate Change, Migration and Displacement: who will be affected", 31 October 2008.

[lxx] Guiding Principles on Internal Displacement (E/CN.4/1998/53/Add.2, annex), principles 1, para. 1, and 6, para. 1 .

[lxxi] Principle 8.2, Principles on Housing and Property Restitution for Refugees and Displaced Persons (endorsed by the Sub-Commission on the Promotion and Protection of Human Rights in resolution 2005/2); FAO/IDMC/NRC/OCHA/OHCHR/UN-Habitat/UNHCR: *Housing and Property Restitution for Refugees and Displaced Persons: Implementing the "Pinheiro Principles",* 2007.

[lxxii] See IASC working paper referred to in footnote 84 above.

[lxxiii] Representative of the Secretary-General on human rights of internally displaced persons,
Displacement Caused by the Effects of Climate Change: Who will be affected and what are the gaps in the normative framework for their protection? background paper, 2008, available at: http://www2.ohchr.org/english/issues/climatechange/submissions.htm.

[lxxiv] In the face of rising sea levels, migration is one adaptation strategy which is already

being implemented in low-lying island States, such as Kiribati, the Maldives, and Tuvalu.
So far this population movement has mainly taken the form of in-country resettlement schemes (IPCC AR4 WGII Report, p. 708).
[lxxv] The papers (E/CN.4/Sub.2/AC.4/2004/CRP.1; E/CN.4/Sub.2/2005/28) were prepared by Françoise Hampson pursuant to a request from the Commission on Human Rights (decision 2004/122) to prepare a report on the legal implications of the disappearance of States for environmental reasons. A questionnaire was prepared in 2006 (E/CN.4/Sub.2/AC.4/2006/CRP.2) with a view to obtaining more accurate data on the nature, scale and imminence of the problem, but as yet no follow-up has been given to this initiative.
[lxxvi] This point was made by Ms. Hampson and other panellists at the consultation meeting organized by OHCHR on 22 October 2008, summary of discussions available at: http://www2.ohchr.org/english/issues/climatechange/docs/SummaryofDiscussions.doc.
[lxxvii] See e.g. Government of the United Kingdom of Great Britain and Northern Ireland, *The National Security Strategy of the United Kingdom: Security in an interdependent world*, 2008 and German Advisory Council on Global Change, *World in Transition - Climate Change as a Security Risk*, 2008.
[lxxviii] As the Chairman of the Nobel Committee stated: "The chief threats may be direct violence, but deaths may also have less direct sources in starvation, disease, or natural disasters" (Presentation speech 10 December 2007).
[lxxix] International Alert and Swedish International Development Cooperation Agency (SIDA), *A Climate of Conflict*, 2008, p. 7. In the same vein, the Special Rapporteur on the right to food observes that conflicts in Africa, including in the Darfur region, are linked to land degradation and related fights over resources (A/HRC/7/5, para. 51).
[lxxx] See e.g. H. Buhaug, N.P. Gleditsch and O.M. Theisen, *Implications of Climate Change for Armed Conflict*, 2008. As the IPCC AR4 WGII Report points out (citing Fairhead, 2004) there are many other intervening and

contributing causes of conflict and many environmentally-influenced conflicts in Africa are related to abundance of natural resources (e.g. oil and diamonds) rather than scarcity, suggesting "caution in the prediction of such conflicts as a result of climate change" (p. 365).

[lxxxi] UNFCCC, art. 4, para. 8, and Kyoto Protocol, arts. 2, para. 3, and 3, para. 14.

[lxxxii] For a discussion of the human rights dimensions of mitigation and adaptation policies see International Council on Human Rights Policy, *Climate Change and Human Rights: A Rough Guide*, 2008, chapter II.

[lxxxiii] Statement of the Special Rapporteur on the right to food, 22 May 2008, at the special session of the Human Rights Council on the global food crisis.

[lxxxiv] See e.g. M. Macchi and others, *Indigenous and Traditional Peoples and Climate Change*, International Union for Conservation of Nature, 2008. CERD expressed concern about plans to establish a large-scale biofuel plantation and the threat it constituted to the rights of indigenous peoples to own their lands and enjoy their culture (CERD/C/IDN/CO/3, para. 17).

[lxxxv] E/C.19/2008/13, para. 45.