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UNDER THE UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE

Climate Change Protection for Present and Future Generation

Ministry of Environment, Republic of Indonesia

Indonesia Second National Communication Under The United Nations Framework Convention on Climate Change (UNFCCC)

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Preface

It is with great pleasure that I have availed myself of the opportunity to present a foreword for the Second National Communication (SNC) of the Republic of Indonesia to the United Nations Framework Convention on Climate Change (UNFCCC).

The devastating impact of global warming is already noticeable in Indonesia and will likely worsen due to further unsustainable economic development and human-induced climate change. Increasingly frequent and severe floods, extreme weather events and prolonged droughts in some regions will lead to further environmental destruction and degradation, human injury and illness. The continuation of warmer temperatures will also increase the number of malaria and dengue fever cases and lead to an increase in other infectious diseases as a result of poor nutrition due to food production disruption.

Indonesia is estimated to have emitted 1.415 Giga tonnes of CO_2 equivalent in the year 2000 with a significant proportion of emissions due to deforestation and land-use change at 1.1 million hectares per year, which accounts for 51 % of the country's annual greenhouse gas emissions. Despite the large emissions from the forestry sector, energy and other sectors contribute only 0.594 Giga tonnes of CO_2-equivalent which is still below the global average.

Regulations regarding environmental protection of the Republic of Indonesia mandate the government to promote and adopt policies that maintain its environment for the benefit of present and future populations. Addressing the challenge of climate change is one of the Indonesian Government's highest priorities, which has committed to a national emission reduction target and is implementing a comprehensive response to climate change in achieving this target, including adaptation to unavoidable climate change. Through its various government agencies and in partnership with the private sector and non-governmental organizations, Indonesia seeks to develop and adopt pre-emptive and corrective actions and activities to address the predicted and actual impacts of climate change.

Indonesia's Second National Communication, to be submitted to the UNFCCC, documents recent emissions, the impacts of Climate Change, as well as Indonesia's efforts in dealing with Climate Change, especially through mitigation and adaptation measures.

Addressing the issue of climate change in Indonesia - with a wide range of complications and territories- requires the attention of a diverse group of experts and key government and non-governmental agencies, coordinated by the Directorate of Climate Change Impact Management under the Deputy Minister of the Ministry of Environment.

This formal document submitted to the UNFCCC was only made possible with financial support from Annex I countries of UNFCCC through GEF (Global Environment Facility).

Finally, on behalf of the Government of the Republic of Indonesia, I wish to acknowledge with gratitude to all these organizations, institutions and individuals who participated in the process of the preparation of the Second National Communication. Your active participation in the deliberations was vital to the success of this project.

Thank you very much.

Prof. Dr. Gusti Muhammad Hatta
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Table of Contents

Executive Summary

Indonesia continues its efforts and actions towards the implementation of the commitments as a Non-Annex I Party to the United Nations Framework Convention on Climate Change (UNFCCC). Indonesia presented its First National Communication to the UNFCCC in 1999. One of the most important parts of the content was the first National Greenhouse Gases Emissions Inventory (NGHGEI) for the year 1990 and also the results of the first studies on the country's vulnerability to climate change. The Second National Communication (SNC) presents National Greenhouse Gases Emissions Inventory (NGHGEI) for the years 2000 to 2005.

This Communication was supported by the Global Environmental Fund (GEF) through the United Nations Development Programme (UNDP), along with further funding from Government of Indonesia. The funds received allowed the improvement of the emissions inventory, and supported the development of studies on climate change mitigation and adaptation in Indonesia. On this occasion, the process of planning the National Communication content included consultations with academics and representatives from government institutions, private sector and non-governmental organizations, in order to capture their opinion and points of view about what elements of the previous communication should be improved in this second assessment. A public consultation was also held for the same purpose.

As requested, Indonesia's Second National Communication was prepared in accordance with the UNFCCC Reporting guidelines on National Communications.

National Circumstances

Indonesia is located between 6°08' North and 11°15' South latitude, and from 94°45' to 141°05' East longitude. The country covers 1,910,931 Km^2. It has five large islands (Sumatra, Java, Kalimantan, Sulawesi and Irian Jaya) and about 13,667 small islands, of which over half (56%) of which are nameless, and only 7% permanently inhabited (Figure 1-1). Extensive coastal plains and mountain areas of 1,000 metres above sea level are characteristics of Sumatra, Kalimantan and Irian Jaya. Of the 200 million ha of land territory, about 50 million ha is devoted to various agricultural activities. There is nearly 20 million ha of arable land, of which about 40% is wetland (rice fields), 40% is dry land, and 15% is shifting cultivation. Since 2005, the Republic of Indonesia has been divided administratively into 33 provinces (BPS, 2008)

The country's population is the fourth most populous nation in the world, following China, India and the United States. The population grew from 119 million in 1971 to 219 million in

2005. While the growth rate is slowing down from 1.49% (1990–2000) to become 1.34% (2001–2005), it is projected that Indonesia's population will reach 300 million in 2030.

Poverty remains a challenge, while unemployment and underemployment are still relatively high. In the Mid-Term National Development Plan (RPJMN) 2004–2009, it was targeted that poverty and unemployment would be about 5.1% and 8.2% respectively. Recent report from BPS stated that the number of unemployment by February 2008 reached 8.46% or about 9.43 million people. However, based on the projection of the Institute for Development Economics and Finance (Indef), due to current economic crisis the number of poor and unemployed in 2008 may increase to 9.5% and 16.3% respectively (Depsos, 2009).

Indonesia's GDP is approximately US$ 175 billion, in which trade (16.7%), manufacturing (28%), agriculture (15.4%), and services (10.17%) are the main contributors. Earnings from exports were about US$ 69 billion (primarily oil and gas, textiles, appliances, coal, copper), while imports accounted for about US$ 44.8 billions (primarily food, chemicals, capitals and consumer goods). GDP growth has increased steadily since 1998, reaching 6.3% in 2007 thus bringing per capita GDP to around US$ 2000.

The role of sectors other than oil and gas has become much more significant in the Indonesian economy since Asian Financial Crisis (AFC), with the oil and gas sectors experiencing negative growth rates each year since with the exception of 2000. Among the non-oil and gas sectors, agriculture has continued to play an important role. It is a sector that was significantly less affected by the AFC, and indeed helped the recovery of Indonesian economy after the crisis through a substantial increase in exports and its absorption of unemployed workers in its role as an "employer of last resort" for many jobseekers (Siregar, 2008).

National GHG inventory

The National Greenhouse Gases Inventory (NGHGI) was estimated using Tier 1 and Tier 2 of the 2006 IPCC Reporting Guidelines and the IPCC GPG for LULUCF. In 2000, total GHG emissions for the three main greenhouse gases (CO_2, CH_4, N_2O, PFC) without LULUCF (LUCF and peat fires) reached **556,728.78** Gg CO_2e. With the inclusion of LULUCF, total net GHG emissions from Indonesia increase significantly to about 1,377,982.95 Gg CO_2e (Table 1a and 1b). The GHG emissions (in CO_2 equivalent) were distributed unevenly between the three gases recorded, i.e. net CO_2 totalled 1,112,878.82 Gg, representing 80.8% of the National GHG emissions; methane (CH_4) totalled 236,617.97 Gg (CO_2e) or 17.2%; and nitrous oxide (N_2O) totalled 28,341.02 Gg (CO_2e) or 2.0%. The main contributing sectors were Land Use Change and Forestry, followed by energy, peat fire related emissions, waste, agricultural and industry.

Table 1a. Summary of 2000 GHG emission and removal (in Gg CO_2e)

	CO_2	CH_4	N_2O	PFC	Total
Energy	247,522.25	30,174.69	3,240.64	NO	280,937.58
Industrial Process	40,342.41	2,422.73	133.22	145.15	43,043.52
Agriculture	2,178.30	50,800.18	22,441.25	NO	75,419.73
LUCF[1]	821,173.35	56.35	24.47	NO	821,254.17
Waste	1,662.49	153,164.02	2,501.45	NO	157,327.96
Total	1,112,878.82	236,617.97	28,341.02	145.15	1,377,982.95

[1]Note: Emission from peat fire was included

Table 1b. Summary of GHG emissions from 2000-2005 from all sectors (in Gg CO_2e)

Source	2000	2001	2002	2003	2004	2005
Energy	280,937.58	306,774.25	327,910.62	333,950.21	372,123.28	369,799.88
Industrial Process	43,043.52	49,810.15	43,716.26	47,901.63	47,985.20	48,733.38
Agriculture	75,419.73	77,500.80	77,029.94	79,828.80	77,862.54	80,179.31
LUCF	649,254.17	560,546.00	1,287,494.79	345,489.33	617,423.23	674,828.00
Peat Fire	172,000.00	194,000.00	678,000.00	246,000.00	440,000.00	451,000.00
Waste	157,327.96	160,817.76	162,800.37	164,073.89	165,798.82	166,831.32
Total With LUCF & peat fire	1,377,982.95	1,349,448.96	2,576,951.98	1,217,243.86	1,721,193.07	1,791,371.89
Total Without LUCF & peat fire	556,728.78	594,902.96	611,457.19	625,754.53	663,769.84	665,543.89

[1]Note: Emission from peat fire was taken from van der Werf et al (2008). [2]Estimated based from MoF (2009) and Bappenas (2009a),
[3]Emission 2001 was not included in determining the trend

The emission estimates in the SNC are lower than those reported by a 2007 PEACE, World Bank and DFID study, which suggested Indonesia to be the 3rd largest emitter country. The study estimated that the total emission from Indonesia was about 3,014,000 Gg CO_2 where LUCF contributed about 85% or about 2,563,000 Gg CO_2 (twice the SNC estimate above). Indeed, a further study from the World Bank (2008) suggested that the mean annual CO_2 emissions from LUCF reached up to 2,398,000 Gg, assuming 53% from peat fire, 20% from peat drainage (peat oxidation), 22% from deforestation and 5% from palm oil and timber plantation establishment. Between the SNC and World Bank estimates, a recent study from DNPI (2009) suggested that the total GHG emissions from LUCF in 2005 reached 1,880,000 Gg CO_2e where about 55% was from peat emissions. These large differences in Indonesian emissions estimates thus appear to be mainly due to differences in estimates of LUCF emissions, particularly from peat.

Inter-annual variation of emissions from peat fires is also very high. High emissions normally occurred in El Nino years (1997, 2002, and 2006). The highest estimate was from Hooijer et al (2006), which estimated the emission based on a Borneo hot-spot count and a carbon calculation method used by Page *et al*. (2002), who estimated emissions from peat fires in 1997 El-Nino. This approach may be give an overestimate as hotspot counts in peat lands are not fully proportional to CO_2 emissions, which are governed by further factors such as the depth and area of burning. Therefore, this relationship may not also be generally applicable for the whole of Indonesia, and so the extrapolation of emission estimates over Indonesia based on limited ground checks in Kalimantan may lead to overestimation.

Van der Werf et al. (2007) attempted to improve emission estimates from peat fires using several sources of satellite data with biogeochemical and atmospheric modeling to better understand and constrain peat fire emissions from Indonesia. This resulted in far lower estimates. The NGHGI adopted the study of the Van der Werf *et al.* (2007). In 2000, their estimated emissions from peat fires were calculated at about 172.000 Gg CO_2e, while the average emission of peat fire (2000-2006) was about 466,000 Gg CO_2e.

Indonesia plans to improve emission estimates, particularly from LULUCF and peat lands in the next National GHG Inventory. At present, activities undertaken by the Ministry of Forestry and Ministry of Agriculture to improve emission estimates from peat lands are the following:

a. The Ministry of Agriculture (through the National Research Consortium for Climate Variability and Climate Change) is conducting studies to develop emissions factors from peat lands under different usage scenarios in Central Kalimantan. The Ministry of Agriculture will also expand this study to other provinces and request support from international agencies. Additional surveys to improve data on peat depth (particularly in Papua) are also being planned. It is expected that the funding allocated for the 3rd National Communication can provide additional support for the studies.
b. The Ministry of Forestry is improving the emission sink factors from forests and emission factors from fire (both in mineral soils and peat land). The programme is being undertaken through the INCAS (Indonesian National Carbon Accounting System) and other relevant research programmes under the MoF and partners.
c. The state Ministry of Environment is conducting a pilot study on Peatland Management, including calculation of GHG emissions from peat lands in West Kalimantan and Riau Province.
d. A detailed analysis commissioned by Indonesia's National Development Planning Agency (BAPPENAS) is also commissioning a detail analysis on peat land emission and projection as well as mitigation strategies. The analysis is undertaken by a multi-disciplinary team of Indonesian scientists, economists and legal specialists.

Steps planned to implement the Convention

To effectively implement the UNFCCC, the Goverment of Indonesia has made a number of significant steps in mainstreaming climate change issues with other national development priorities. The first of these was the issuance of the National Action Plan on Climate Change (MoE, 2007a), which describes appropriate actions to reduce GHG emissions and adaptation activities in Indonesia. This was then followed by a further document, "National Development Planning: Indonesia responses to climate change", called as Yellow Book. The National Development Planning Agency (Bappenas) subsequently developed a Climate Change Sectoral

Roadmap (ICCSR), meant to bridge the National Action Plan on Climate Change into the 5 year Mid-Term Development Plan (RPJM) 2010-2014, and to provide inputs for the subsequent RPJMN until 2030. The process of developing the Climate Change Roadmap is shown in Figure 1.

To support and accelerate the implementation of climate change programs, the Government of Indonesia established a number of innovative ways to link international financial resources with national investment strategies. This Indonesian Climate Change Trust Fund (ICCTF; Bappenas, 2009b) aims to be a showcase of alternative financing for climate change mitigation and adaptation programs. At this stage, the ICCTF has five specific objectives namely (i) to facilitate and accelerate investment in renewable energy and efficiency and simultaneously reduce GHG emissions from the energy sector, (ii) to reduce emission from deforestation and forest degradation and stabilizing carbon stock through sustainable forest and peat land management, (iii) to reduce vulnerability in coastal zones, agriculture and water sectors, (iv) to bridge the financial gaps necessary to address climate change mitigation and adaptation and (v) to increase the effectiveness and impact of external finance for climate change programs.

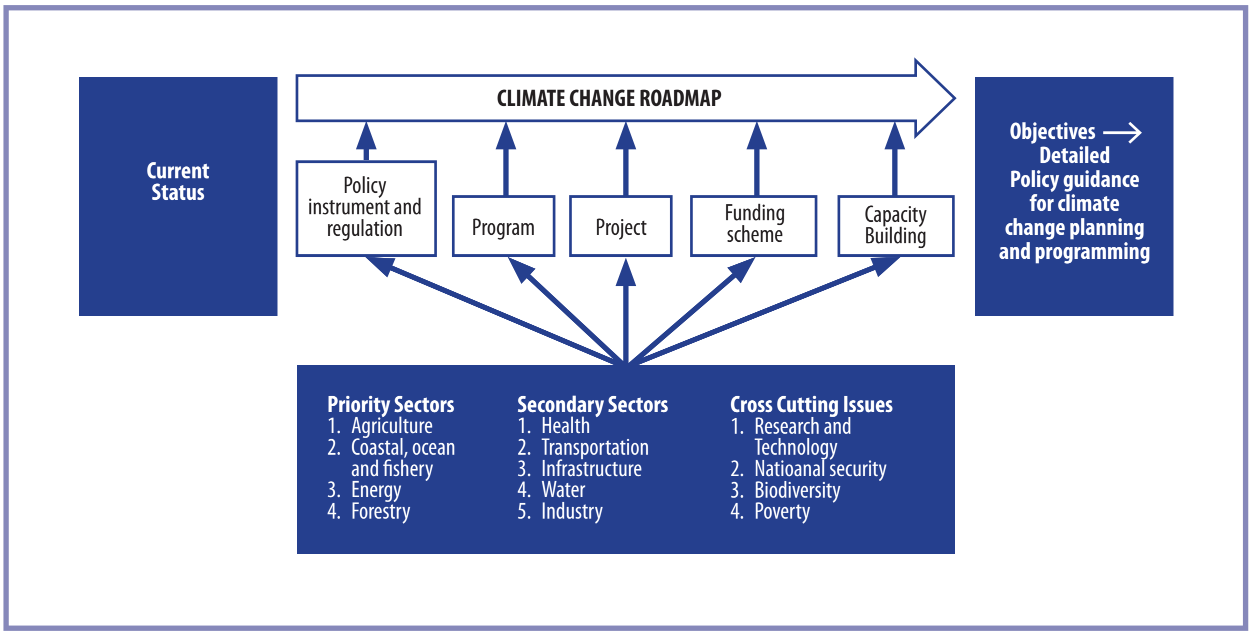


Figure 1. Process of Development of Climate Change Sectoral Roadmap (ICCSR)

Following commitment of the GOI to actively participate in reducing its emissions through National Appropriate Mitigation Action (NAMA), in 2009, the President of the Republic of Indonesia at the G-20 meeting inPittsburgh and at COP15 in Copenhagen committed to an ambitious, world-leading target of 26% reduction in carbon emissions from Business As Usual (BAU) by 2020. Further emissions reductions of 41% are expected with international support. With this commitment, Indonesia will follow a low carbon development path. As such, BAPPENAS is coordinating the sectors to develop the National Action Plan for Reducing Greenhouse Gas Emissions (RAN-GRK). The GOI lists three principles in the RAN-GRK, stating that the mitigation actions (i) should not hinder economic growth, and should prioritize people's welfare, especially in with regard to energy resilience and food security, (ii) support protection of poor and vulnerable communities, including environment conservation in the framework of sustainable development and (iii) consist of core activities to reduce emissions and supporting activities to strengthen the policy framework. Figure 2 shows the interconnection between policies, guidelines, roadmaps and investment funds towards low carbon development. One new source of funds to support the implementation of climate change programs in Indonesia is the Indonesian Climate Change Trust Fund (ICCTF), described briefly in the following section.

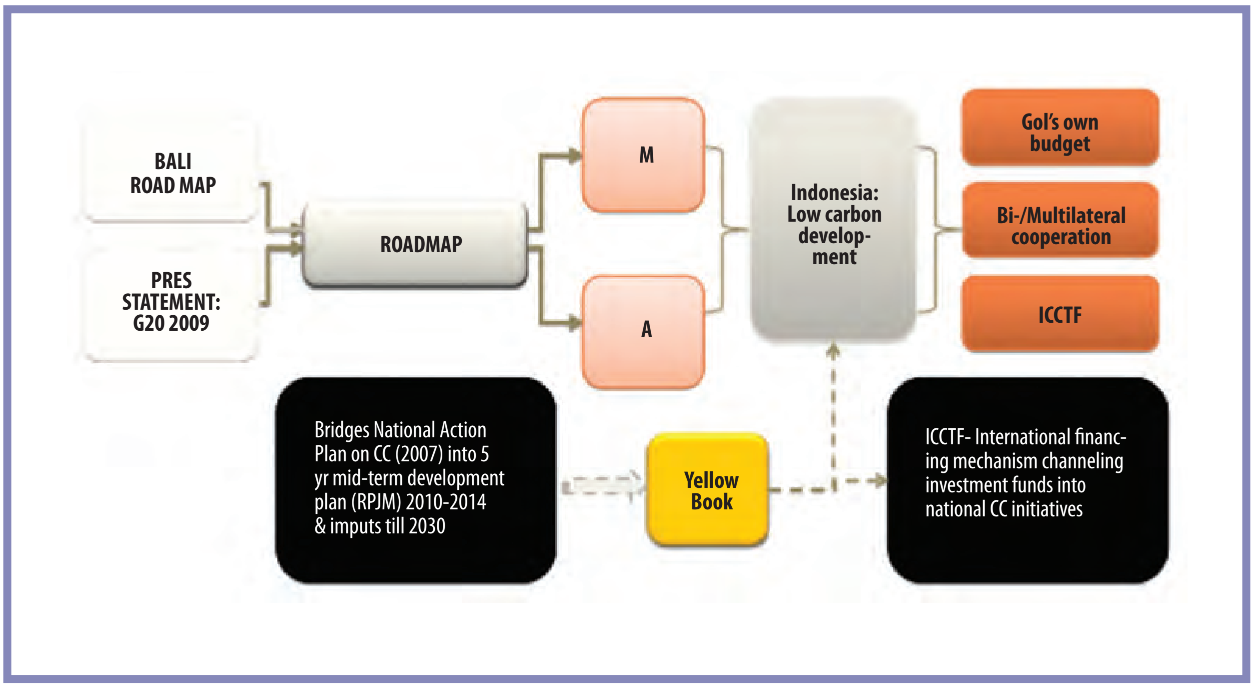


Figure 2. Process of mainstreaming climate change into national agenda: Policies, guidelines, roadmaps & investment funds (BAPPENAS, 2009b). Note: M is mitigation and A is adaptation.

Measures to Facilitate Adequate Adaptation to Climate Change

Due to its geographical location, topography and socioeconomic aspects, Indonesia is especially vulnerable to the impacts of climate variability and climate change. The El Niño and La Niña phenomena (ENSO), as well as extreme meteorological conditions, have historically resulted in serious damage that affects a wide range of different socioeconomic sectors. A number of studies suggested that El Niño events have become more frequent as the global temperature anomalies associated with each El Niño continue to increase (Hansen et al., 2006; Timmerman et al. 1999). This suggests that the increasingly high temperatures are exacerbating the extreme regional weather and climate anomalies associated with El Niño.

By assessing historical natural hazard data from 1907-2007 (OFDA/CRED International Disaster Database 2007), it is clear that the first climate-natural hazard categorized as global hazard occurred for the first time in early 1950s; by the 1980s they were occurring more frequently. Over this entire record, the most frequent hazard has been flooding, followed by landslides and water or vector borne diseases, wind storms, forest fires, drought, and high tide/storm surge.

Furthermore, the top 20 natural hazards, causing huge economic loss and adverse human impacts, mostly occurred after the 1980s, suggesting increasing trend in hazards' intensity (Boer and Perdinan, 2008).

With the increasing trend of climate hazards frequency and intensity, the most affected group will be the poorest sections of society, which are most exposed and least resilient. The capacity of this group to adapt to the extreme climate events and future climate change is limited due by their limited resource availability and access to climate information and technologies. It is likely, therefore, that their reliance on national and local public assistance from government will increase in the future. During the 2006/07 El-Nino, many farmers in the Timor district of East Nusa Tenggara Province—one of the most vulnerable districts to drought--experienced crop failure due to drought. As a consequence, the major source of income for the poorest came from government aid ('*bantuan pemerintah*'). In addition to aid, many of farmers often have to sell their domestic livestock (*ternak*) or engage in informal laboring to generate additional income. At Indramayu, the drought occurrence associated with the 2002/03 El-Nino caused huge rice production loss. In 2003, the number of household that could not meet their food basic needs increased by 14% compare to the normal years (Boer et al., 2006).

It is clear, therefore, that improving access to a diversified set of incomes and resources is a key method for improving climate resilience. This is closely linked with rapid poverty reduction, which is essential to help poor and vulnerable communities improve their resilience both to natural climate variability and to the greater stresses of human-induced climate change in the future.

Observed Climatic Changes and Predictions. Analysis of long historical climate data suggests that maximum and minimum temperature have increased consistently (MoE, 2007). Significant decreases and/or increases in rainfall have also detected in many part of Indonesian region, with different significant trends in different areas. Based on data over 300 stations, with length of records between 20 and 50 years, a significantly decreasing trend in Dec-Jan rainfall was observed in small part of Java and Papua, and Sumatra and large part of Kalimantan islands, whereas significant increasing trend were observed in most of Java and Eastern Indonesia such as Bali, NTB and NTT (Figure 3). For Jun-Aug rainfall, significantly decreasing trends were observed in most of Indonesian region with exception in Pandeglang (West Java), Makasar (South Sulawesi), Monokwari, Sorong (Irian Jaya) and Maluku (Figure 3).

Monsoon onset has also changed in many part of Indonesia. Based on analysis of data from 92 stations spread over Indonesia, monsoon onset has increasingly been delayed in some part of Indonesia, particularly in Java; similarly, the length of the wet season has tended to shorten, particularly in South Sumatra, Java and Kalimantan. Other studies conducted in East Java also suggest that the number of extreme dry months in the Brantas Catchment area has increased in the last five decades, particularly in areas near to the coast (Aldrian and Djamil 2006). In such coastal areas, the number of extreme dry months increased to 4 months in the last ten years and in 2002 it reached 8 months, a level considered as the longest dry season for the whole five decades. In mountain areas, the number of dry months is about 1-2 months over the last ten years, with maximum number of 4 months.

Using 14 General Circulation Models (GCMs), under increasing GHG emission scenarios (SRESA2), most of models are in agreement that in 2025 the wet seasonal rainfall (DJF) in Java, Bali, NTB, NTT and Papua will increase, while in other parts will decrease. By 2050 and 2080, most of Indonesian regions will experience higher rainfall than current condition, with exception in northern part of Sumatra and Kalimantan (Figure 5). Furthermore, dry season rainfall in most parts of Java might decrease in 2025, increase again in 2050, and then decrease in 2080, particularly in West Java and South Sumatra (Figure 5). Under low emission scenarios (SRESB1), the pattern of change is similar to that of high emission scenarios but the magnitude of change is slightly lower.

The monsoon onset more generally in Java and Bali may also delay under warming atmosphere. It is clear that a 30-day delay in monsoon onset is very likely to occur more frequently in 2050 than it does today and the length of the rainy season will shorten (Naylor et al., 2007).

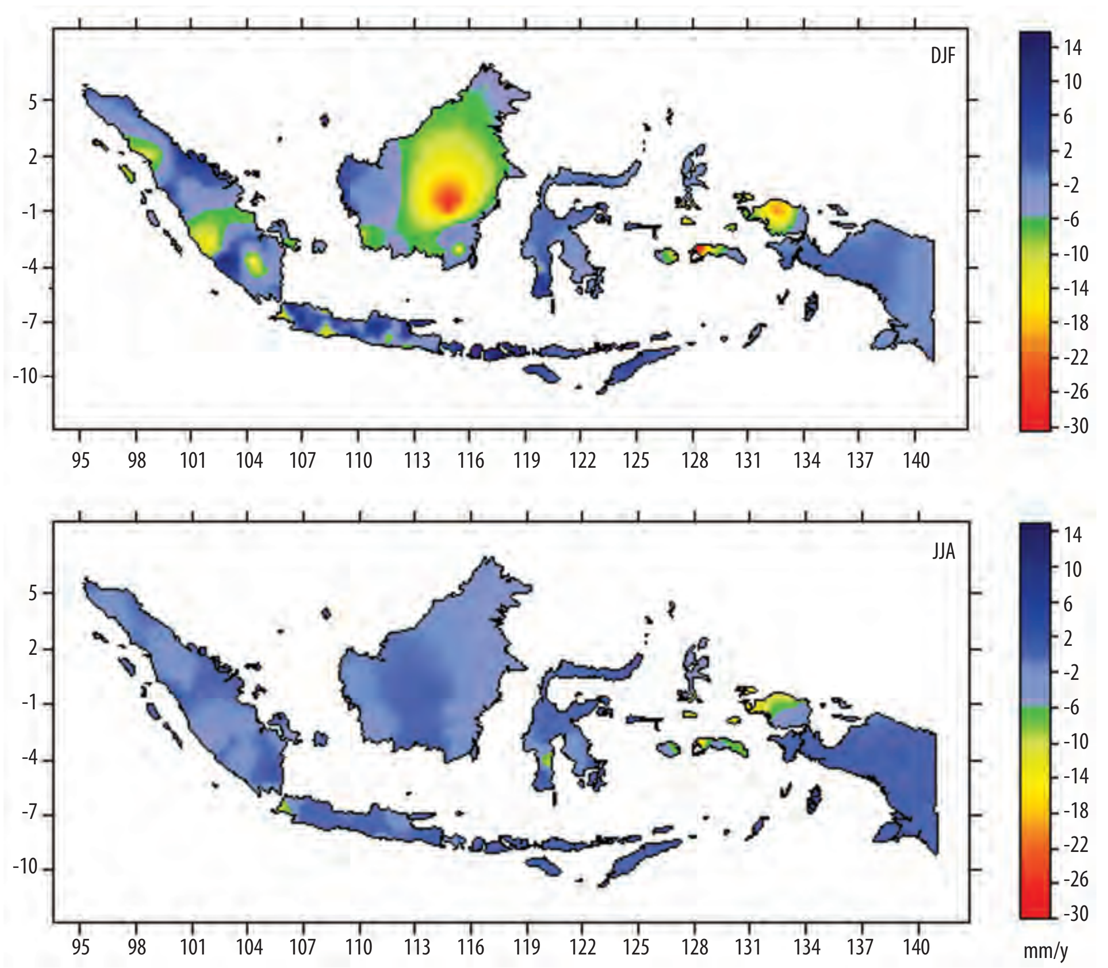


Figure 4. Trend of seasonal rainfall for Dec-Feb (above) and June-Aug (below) in Indonesia (Source: Boer et al., 2009a)

Global warming is also very likely to increase sea levels. Historical data shows increasing trends in mean sea level (MSL) in a number of locations. However, the rate of increase varies with locations (Sofian, 2009). The relative sea level rise accelerates significantly in areas where coastal erosion is removing material and where the land border has been subsiding. The increase in MSL has also increased the problem of saltwater intrusion and salinity.

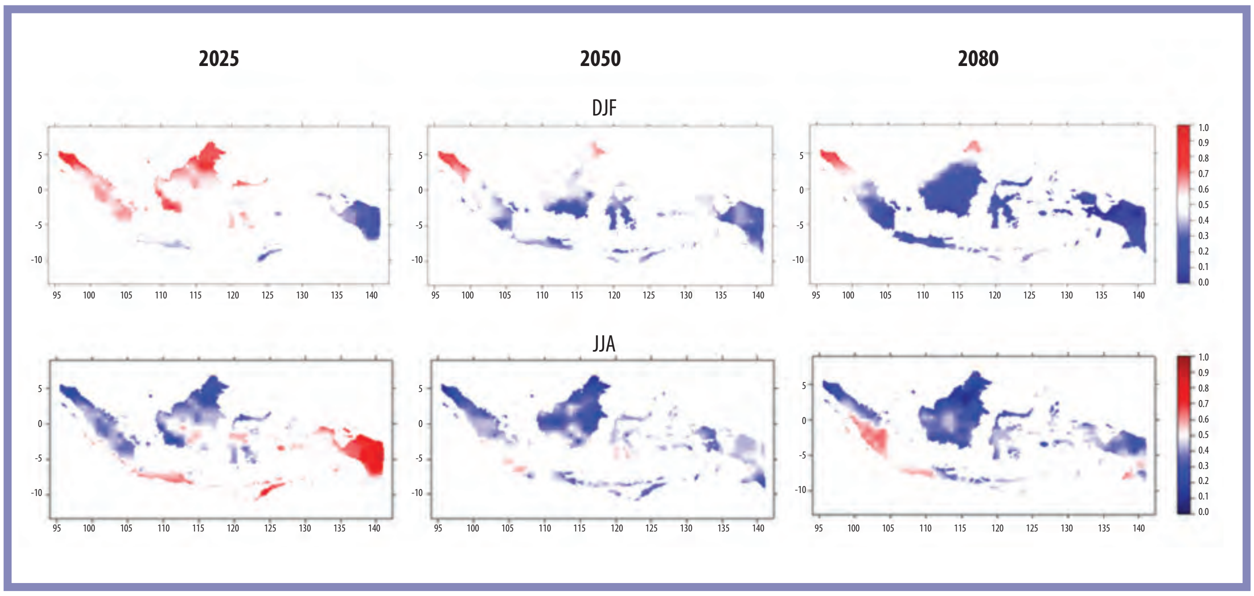


Figure 5. Trend of wet seasonal (December-February) and dry seasonal (Juny-August) rainfall under high emission scenarios (SRESA2). Note: Dark Red (indicator 1) means that all GCM model are in agreement to suggest the seasonal rainfall will decrease and dark blue (Indicator 0) means that all models are in agreement to suggest the seasonal rainfall will increase (Boer et al., 2009a).

Sector-Wise impacts and Adaptation Measures. Changes in spatial rainfall patterns, the length of the wet season and inter-seasonal variability will have serious implications for many sectors. In the agriculture sector, the current cropping pattern may no longer be the most effective food production system. At present, the pattern used in most of the rice growing areas of Indonesia is rice-rice. The second planting depends heavily on irrigation water. Under extreme drought years, the availability of irrigation water is very limited, usually leading to major rice production losses. Under a changing climate, the occurrence of extreme climate events (drought) will be more frequent than the current climate and there is a possibility that the dry season will persist for longer periods. Therefore, keeping this cropping pattern in the future may expose Indonesian farmers to more frequent crop failures. Thus, in areas where the pattern of rainfall changes in this direction, farmers should consider alter their cropping pattern from rice-rice to rice-non rice. If the rice-rice pattern is maintained, improvement of water storage and irrigation facilities will be required for compensating the decreased in JJA rainfall. More efforts to create new short maturing rice varieties should also be in place to anticipate the shorter wet season
The increase in temperature and the changes in rainfall pattern and length of seasons may also trigger the development of crop pests and diseases. Field observations in a number Java districts, such as Indramayu, Magelang, Semarang, Boyolali, Kulonprogo, and Ciamis, provide the evidence of this phenomena (Wiyono, 2007).

Furthermore, analysis of climate change impacts in rice production in Java suggested that production between 2025 and 2050 is likely to decrease by about 1.8 and 3.6 million ton from the current production level respectively (Boer *et al.*, 2009b). By including the impact of rice field conversion to non-agriculture lands in Java, i.e. taking 0.77% of land out of production per annum, the production loss in 2025 and 2050 will increase to 5.2 and 13.0 million ton respectively. Thus, the impact of rice field conversion will be much higher than the impact of climate change. To compensate this loss, new rice areas of around1.5 and 3.5 million ha will be needed in 2025 and 2050 respectively outside Java. Alternatively, the loss can be compensated by increasing rice productivity by about 20% and 50% from the current levels. To achieve this, breeding technology would have to be able to increase rice productivity by about 1 t/ha and 2.5 t/ha from the current productivity (~5 t/ha).

A rapid assessment conducted by Parry *et al*. (1992) in a number of locations in Indonesia suggested that sea level rise due to global warming will also reduce local rice supply in Krawang and Subang districts by about 300,000 tonnes. Similarly, maize output would likely be reduced by 10,000 tons--about half of this due to inundation. Sea-level rise would also be likely to affect fish and prawn production. The loss is estimated at over 7000 tonnes and 4000 tons respectively (valued at over US$0.5m). In the lower Citarum Basin sea-level rise could result in the inundation of about 26,000 ha of ponds and 10,000 ha of crop land. This could result in the loss of 15 000 tons of fish, shrimp and prawns and about 940 000 ton of rice. Parry et al. stated that the socio-economic implications of this transition in Subang District alone could be the loss of employment for about 43 000 farm laborers. In addition more than 81 000 farmers would have to look for other sources of income due to the inundation of their rice fields or prawn and fish farms due to sea-level rise.

For water resources, the present condition of the water balance suggests that in most of Java and the eastern islands of Indonesia is already in deficit for most of year. With such conditions, increasing planting in these islands is not possible, further restricting options for increasing rice production outlined above. Under changing a climate, more districts will have water scarcity problems (Heriensyah et al., 2009). A key need is the development of new initiatives to anticipate the scarcity of water due to climate change and increases on water demand, especially in urban areas where populations are increasing and industrial activities are taking place. Inter-basin transfer of water may be one of the potential options to anticipate the scarcity of water in the future. In Indonesia many basins have surplus water resources, even in the ultimate stage of development, while others face serious shortages, especially during extreme drought years. Creation of storages and inter-basin transfer of water from surplus to deficit regions (such as in West Nusa Tenggara) could therefore be an option for achieving more equitable distribution of resources and their optimal utilization.

For coastal and Outer Islands, the increase in sea level by about 25 to 50 cm in 2050 and 2100 as projected by many models will inundated many parts of the coastal cities of Indonesia. Land subsidence will exacerbate this, increasing the total area that will be inundated permanently. Between 25% and 50% of area in a number of sub-districts in coastal cities such as Semarang, Surabaya, Jakarta and Medan will be under water permanently. The increase of sea level rise may also inundate the outer islands of the country, and this will affect the area of Indonesian territory. The analysis suggests that an increase of sea level of up to 50 cm will not inundate the outer islands of Indonesia permanently. However, in combination with tidal patterns in the region, about five outer islands will temporarily inundate. These islands include Alor (next to Timor Leste), Pelampong (next to Singapura), Senua (next to Malaysia), Simuk and Sinyaunyau (next to India).

The increase in sea temperature will also caused serious problems for the coral ecosystems. Wetland International (Burke *et al.,* 2002) reported that the 1997 El-Niño damaged about 18% of the coral ecosystems in South East Asia. In Indonesia, coral bleaching was observed in many places such as in the eastern part of Sumatra, Java, Bali, and Lombok. In 'thousands islands' (north of the Jakarta coast), about 90-95% of the corals located 25 m below sea surface have been bleached.

For forests sector, the decreasing dry season rainfall and shortening length of wet season will increase the risk of forest fire. Two islands which are very prone to fire are Sumatra and Kalimantan. Based on hotspot density patterns, two provinces that have very high hot spot density are Riau Province and Central Kalimantan. Hotspot densities in these two islands increased rapidly when dry season rainfall decreases or length of dry season extends, particularly during El Nino years. It was revealed that the hot spot density increase rapidly as the monthly rainfall in dry season by more than 50 mm below normal (Ardiansyah and Boer, 2010).

For health, extreme weather related to ENSO also contributes to the outbreak of human diseases such as malaria, dengue, diarrhea, cholera and other vector borne diseases. Dengue cases were found to increase significantly in La-Niña years when seasonal rainfall levels increased above average. A significant upward trend in the number of dengue cases was also observed in Java, especially in large cities. In the future, under changing climate it is likely that the risk of transmission of dengue and malaria may well increase (Hidayati et al., 2009).

All sectors have developed a number of measures to increase the capacity to address and to increase resilience to current and future climate risks respectively. The programs are described in the Yellow Book and the sectoral roadmap to address climate change (Bappenas, 2009a and 2009 b).

Measures to Mitigate Climate Change

The impact of implementation of mitigation options on the level of GHG emission is evaluated by comparing the emission level under Business as Usual (BAU) with emission level under two mitigation scenarios. Based on the emissions projection analysis, net emissions under BAU in 2020 are expected to be approximately 2.95 Gt CO_2 – more than double the emissions in year 2000. It was found that by 2020, the rate of emissions under mitigation scenario 1 reached about 31% of that of the BAU and under mitigation scenario 2, it could reduce up to about 48% (Figure 6).

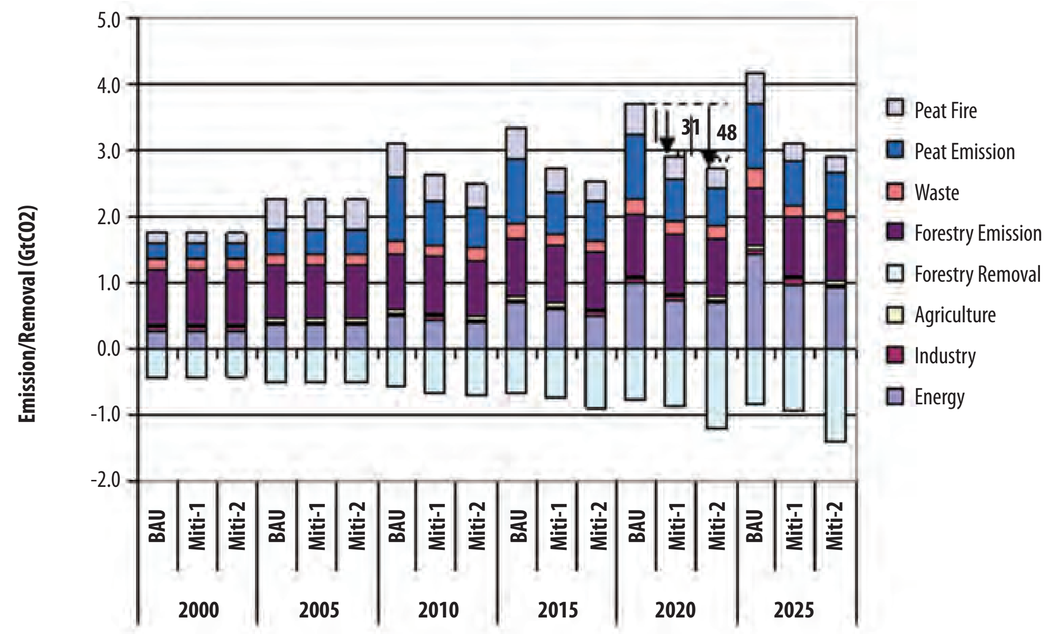


Figure 6. Projection of emissions of all sectors under BAU and mitigation scenarios (MoE, 2009). Note: Contribution of transportation sector to the total energy emission is approximately 20% (based on emissions data from 2000-2006).

In energy sector, reducing of the emission from the BAU will be done through additional efforts related to energy conservation and new and renewable energy development (i.e. enhance geothermal program, micro-hydro, biofuel, biomass waste to energy, solar PV, wind energy and coal bed methane [CBM]). In industry sector, emission reduction will be done by increasing the efficiency in production processes, introduction of new technologies, or by changing the raw materials (i.e., using waste as an alternative material in the cement industry). The efforts can be achieved through the clean development mechanism (CDM) scheme and private sector participation. Public funding is still needed for the dissemination of programs related to CO_2 emissions reductions in industrial processes.

In Agriculture sector, the key mitigation program will be through (i) implementing no-burning technology for land clearing, specifically in the horticulture and agriculture plantation sub-sectors, (ii) developing a Fire Early Warning System particularly in peat areas, (iii) introducing low methane emitting rice varieties, (iv) increasing the use of agriculture waste for bio-energy and composting, (v) introducing biogas technology, (vi) improving feeding quality and supplementation for livestock and (vi) developing new agriculture areas which will be directed to unproductive land such as grassland and abandoned land through revitalization of agriculture spatial plan program. In forestry sector, the mitigation measures will be done through (i) combating illegal logging and its associated trade, (ii) revitalizing forestry industries, (iii) conserving and rehabilitating forest resources, (iv) empowering the economy of the community within and surrounding the forest area, and (v) stabilizing forest area for promoting and strengthening sustainable forest management. In waste sector, the emission reduction from solid waste will be done through converting the open dumping practices to a more managed solid waste handling system (i.e., a sanitary landfill equipped with gas flaring or utilization systems), and handling liquid domestic waste using sewerage systems.

Following commitment of the GOI to actively participate in reducing its emissions through National Appropriate Mitigation Action (NAMA), in 2009, the President of the Republic of Indonesia at the G-20 meeting in Pittsburgh and at COP15 in Copenhagen committed to an ambitious, world-leading target of 26% voluntary reduction in carbon emissions from Business As Usual (BAU) by 2020. Further emissions reductions of 41% are expected with international support. With this commitment, Indonesia will follow a low carbon development path. As such, BAPPENAS is coordinating the sectors to develop the National Action Plan for Reducing Greenhouse Gas Emissions (RAN-GRK). The GOI lists three principles in the RAN-GRK, stating that the mitigation actions (i) should not hinder economic growth, and should prioritize people's welfare, especially in with regard to energy resilience and food security, (ii) support protection of poor and vulnerable communities, including environment conservation in the framework of sustainable development and (iii) consist of core activities to reduce emissions and supporting activities to strengthen the policy framework

Other Information

Other information considered relevant to the achievement of the objectives of the Convention includes (i) technology transfer, (ii) Research, (iii) systematic observations, (iv) information on education, training, public awareness and capacity-building and (v) efforts to promote information sharing. The role of NGOs in the implementation of adapatation and mitigation activities with local communities is quite significant. In general, NGOs play their roles as implementer and facilitator of CDM projects as well as voluntary carbon projects.

To accelerate the development of mitigation and adaptation technologies, the Government of Indonesia under the coordination of the Ministry of Agriculture has established the Research Consortium on Climate Variability and Climate Change. To monitor climate and sea level, the Government of Indonesia has installed rainfall stations in all Indonesia regions, a number of automatic weather stations (AWS) and radar in a number of places particularly in areas prone to weather/climate hazards, one Global Atmospheric Watch (GAW) in Bukittinggi, West Sumatra as part of the global atmospheric observation under World Weather Watch.

In forestry sector, development of systematic forest and land use monitoring systems is also crucial to support the implementation of programs for reducing emission from deforestation and forest degradation. The Government of Indonesia is in the process of establishing Indonesia's National Carbon Accounting System (INCAS), based on Australia's system but tailored to

Indonesia's (INCAS) unique circumstances. In addition, Indonesia is developing Indonesia's Forest Resource Information System (FRIS), a comprehensive and transparent information management system to support effective planning and forest management decision making for forest lands in Indonesia.

Capacity building activities related to climate change were also quite significant but many of the activities were conducted at national level. To promote information sharing related to climate, many agencies have established a Web-based climate information system.

Barriers, and Related Financial, Technical and Capacity Needs

As developing country, Indonesia has several limitations in funding in the frame of climate change anticipation as well as developing and disseminating environmentally friendly technology. Therefore, the problems of technology transfer and funding are two issues that should receive support from international community. Additional important activities, which will ensure success of mitigation and adaptation program, are awareness, education, empowerment and capacity building.

To meet financial need for addressing climate change problem, the GOI Indonesia has created various funding schemes, from domestic sources as well as from bilateral and multilateral sources. One of important funding sources is Indonesian Climate Change Trust Fund (ICCTF). At the initial phase, the ICCTF will be created as an "Innovative Fund," which involves grant funding from development partners that will help overcome barriers for early program deployment. At the later stages, the ICCTF may advance by establishing a "Transformation Fund" mechanism, which would involve all available funding (i.e., public-private partnerships, loan and world capital market sources)

The immediate need to mitigation technology for Indonesia is the energy efficient technology particularly for sectors that consume energy such as power plants, industry, transportation, as well as household and commercial sectors. Real time monitoring and the use of sophisticated fire fighting technology and peat management is also required to control emission from forest/ peat fire and peat decomposition. To increase the resilience to current and future climate risk, the development and implementation of a comprehensive communications strategy to increase the capacity in using climate information is also needed as well as institutionalizing the use of climate information. The development and promotion of tools for adaptation planning tailored to user's requirements that include (i) decision-support tools such as methods for assessing the costs and benefits of adaptation strategies, and guides for risk management, (ii) methods for understanding social impacts, and (iii) a national 'one stop shop' website where decision-makers and their advisers can access information about climate projections, likely climate change impacts, tools, guides and approaches to adaptation planning will also be required.

List of Figure

List of Table

Glossary of Abbreviations

EDM	=	Empirical Downscaling Model
AD	=	Activity Data
ADB	=	Asian Development Bank
ADPC	=	Asian Disaster Preparedness Centre
ADRC	=	Asian Disaster Reduction Center
AFC	=	Asian Financial Crisis
Al	=	Aluminum
AMJ	=	April, May, June
APL	=	Area Penggunaan Lain (Other land uses)
APPI	=	Association of Fertilizer Producers
AR	=	Afforestation and Reforestation
AS	=	Ammonium Sulfate
AWS	=	Automatic Weather Stations
BALITKILIMAT	=	Research Agency on Agro-climatology and Hydrology
BAPLAN	=	Directorate General of Planology
BAPPENAS	=	National Agency for Planning and Development
BAU	=	Business as Usual
BBSLDA	=	Center for Agiculture Land Resources and Development
BI	=	Births
BMKG	=	Meteorology, Climatology, and Geophysical Agency
BOD	=	Biological Oxygen Demand
bpd	=	barrels per day
BPPT	=	Agency for Technology Assessment and Application
BPS	=	Badan Pusat Statitistik (Indonesian Bureau of Statistics)
BPSDA	=	Balai Pengelolaan Sumberdaya Air
C	=	Confidential
CBM	=	Coal Bed Methane
CCROM-IPB	=	Centre for Climate Risk and Opportunity Management-Bogor Agriculture University
CCS	=	Carbon Capture and Storage
CDM	=	Clean Development Mechanism
CFBC	=	Coal Fluidized Bed Combustion
CH_4	=	Methane
CI	=	Cropping Index
CIFOR	=	for International Forestry Research
CL	=	Crops Land
CO_2	=	Carbon Dioxide
CO_2e	=	Carbon Dioxide Equivalent
COP	=	Conference of Parties
COP13	=	13th Conference of Parties
COP15	=	15th Conference of Parties
COREMAP	=	Coral Reef Rehabilitation and Management Program
CRED	=	Center for Research on the Epidemiology of Disaster
CWPB	=	Centre-Worked Prebake
Depsos	=	Ministry of Social
DFID	=	United Kingdom Department for International Development
DJF	=	December, January, February
DNM	=	Directorate for Nature and Management
DNPI	=	National Committee on Climate Change
DNS	=	Debt for Nature Swaps
DOC	=	Degradable Organic Content
EE	=	Energy Efficiency
EF/RF	=	Emissions Factor/Removal Factor
EFBs	=	Empty Fruit Bunches
ENSO	=	El Niño Southern Oscillation
f	=	Fraction of rainfall that cannot be utilized
FBS	=	Feed Supplement Blocks
FCCP	=	Forestry-Climate Change Project
FCPF	=	Forest Carbon Partnership Facility
FMU	=	Forest Management Unit
FMUs	=	Forest Management Units
GAW	=	Global Atmospheric Watch
GCMs	=	General Circulation Models
GDP	=	Gross Domestic Product
GEF	=	Global Environment Facility
GEF	=	Global Environmental Fund
GFC	=	Global Financial Crisis
GFF	=	Global Forest Fund
GHGs	=	Greenhouse Gases
GL	=	Guidelines
GL	=	Grass Land
GOI	=	Government of Indonesia
GPG	=	Good Practice Guidance
NFI	=	National Forest Inventory
H_2S	=	Hydrogen Sulfide
ha	=	Hectare
HDI	=	Human Development Index
HK	=	Conservation Forest
HL	=	Protection Forest
HoB	=	Heart of Borneo
HP	=	Production Forest
HPK	=	Convertible Production Forest
IAARD	=	Indonesian Agency for Agriculture Research and Development
ICCTF	=	Indonesian Climate Change Trust Fund
IDR	=	Indonesia Rupiah
IE	=	Including Elsewhere
IFCA	=	Indonesian Forest Climate Alliance
IGCC	=	Integrated Gasification Combined Cycle
INCAS	=	Indonesian National Carbon Accounting System
INDEF	=	Institute for Development Economics and Finance
IndTEWS	=	Indonesia Tsunami Early Warning System

Inpres	=	Presidential Instruction
IP0	=	Current Planting Index
IPB	=	Bogor Agriculture University / Institut Pertanian Bogor
IPCC	=	Intergovernmental Panel on Climate Change
IRI	=	International Research Institute for Climate and Society
ITB	=	Bandung Institute of Technology
ITCZ	=	Inter-tropical Convergence Zone
JAS	=	July, August, September
JJA	=	June, July, August
KAfarm	=	Water demand for agriculture
KAindustry	=	Water demand for industrial sectors
KApopulation	=	Water demand for domestic use
kc	=	Crop Coefficient
NTB	=	West Nusa Tenggara
KEN	=	National Energy Policy
Kep. MENLH	=	Decree of the State Minister of Environment
Kepmen Ekuin	=	Ministerial Decree
Km	=	Kilometer
LAPAN	=	National Agency for Aviation and Space
LFG	=	Landfill Gas
LIPI	=	The Center for Oceanography Research of the Indonesian Institute of Science
LPG	=	Liquified Petroleum Gas
LPMH	=	Harvested Area During the Wet Season
LPMK	=	Harvested Area During the Dry Season
LPTP	=	Lembaga Pengembangan Teknologi Pedesaan
LUCF	=	Land Use Change and Forestry
LULUCF	=	Land Use, Land Use Change and Forestry
MAM	=	March, April, May
MDGs	=	UN Millennium Development Goals
MEMR	=	Ministry of Energy and Mineral Resources
MEWS	=	Meteorological Early Warning System
MH	=	Wet Season
MK	=	Dry Season
MMBOE	=	Million Barrel Oil Equivalent
MoA	=	Ministry of Agriculture
MoF	=	Ministry of Forestry
MRT	=	Mass Rapid Transport
MRV	=	Reporting and Verification
MSE	=	Ministry of State of Environment
MSW	=	Municipal Solid Waste
MW	=	Megawatts
N	=	Nitrogen
N2O	=	Nitrous Oxide
NA	=	Not Applicable
NAD	=	Nanggroe Aceh Darusalam
NAMA	=	National Appropriate Mitigation Action
NAO	=	North Atlantic Oscillation
NE	=	Note Estimated
NGHGI	=	The Indonesian National Greenhouse Gas Inventory
NGOs	=	Environmental non-Governmental Organizations
NO	=	Not Occurring
NPK	=	Nitrogen, Phosphorus And Potassium
NTFP	=	Non Timber Forest Product
NTT	=	East Nusa Tenggara
ODA	=	Official Development Assistance
ODA	=	Overseas Development Assistance
OFDA	=	Office of U.S. Foreign Disaster Assistance
OM	=	Organic Matter
P	=	Population Density
PDO	=	Pacific Decadal Oscillation
PEACE	=	Pelangi Energi Abdi Citra Enviro
Permenhut	=	Ministry of Forestry Regulation
PERPRES	=	Presidential Decree
PFCs	=	Perfluorocarbons
PLN	=	National Electricity Enterprise
PP	=	Pregnancy Period
PP	=	Polypropylene
PP	=	Government Regulation
PU	=	Ministry of Public Works
QA/QC	=	Quality Assurance/Quality Control
RAN-GRK	=	National Action Plan for Reducing Greenhouse Gas Emissions
REDD	=	Reducing Emissions from Deforestation and Forest Degradation
REL	=	Reference Emission Level
RKP	=	Rencana Kerja Pemerintah
Rmonthly	=	Monthly Rainfall
RPJMN	=	The Mid-Term National Development Plan
RUKN	=	General Plan of National Electricity
RUPTL	=	Business Plan of Electricity Supply
SCCF	=	Special Climate Change Fund
SGP-GEF UNDP	=	Small Grant Program-Global Environmental Facility UNDP
SIGN	=	Sistem Inventarisasi Gas Rumah Kaca Nasional
SLR	=	Sea Level Rise
SNC	=	Second National Communication
SNI	=	National Standard
SON	=	September, October, November
SSTs	=	Sea Surface Temperatures
SWDS	=	Solid Waste Disposal Site
SWS	=	Satuan Wilayah Sungai
TC	=	Technical Cooperation
TERANGI	=	Indonesian Coral Reef Foundation
TOW	=	Total Organic Waste
TP	=	Potential Transmissions
UNDP	=	United Nations Development Programme
UNEP	=	United Nations Environment Programme
UNFCCC	=	United Nations Framework Convention on Climate Change
UN-OCHA	=	United Nations Office for Coordination of Humanitarian Affairs
USD	=	United State Dollar
USDA	=	United State Department of Agriculture
WHO	=	World Health Organization
WRI	=	World Resources Institute
WWF	=	World Wildlife Fund
WWT	=	Wastewater Treatment

CHAPTER I

National Circumstances

1.1 Geography and Climate

Indonesia is located between 6°08′ North and 11°15′ South latitude, and from 94°45′ to 141°05′ East longitude. The country covers 790 million hectares (ha), with a total coastline of 81,000 km and land territory of about 200 million ha. It has five large islands (Sumatra, Java, Kalimantan, Sulawesi and Irian Jaya) and approximately 13,667 small islands, of which more than half (56%) are nameless and only 7% are permanently inhabited (Figure 1.1). Extensive coastal plains and mountain areas of 1,000 metres (m) above sea level are characteristics of Sumatra, Kalimantan and Irian Jaya. Of the 200 million ha of land territory, about 50 million ha are devoted to various agricultural activities. There is nearly 20 million ha of arable land, of which about 40% is wet-land (e.g., rice fields), 40% is dry land, and 15% is shifting cultivation. Since 2005, the Republic of Indonesia has been divided administratively into 33 provinces.

Figure 1.1 Map and overview of Indonesia, 2007

Indonesia's climate is dominated by monsoons, which give a degree of homogeneity across the region. Indonesia lies across the range of the Inter-tropical Convergence Zone (ITCZ) where the northeast and southeast trade winds penetrate the doldrums. Strong ascending motion, overcast skies, strong squalls, heavy rainfall and severe local thunderstorms with variable intensities are characteristics of this zone.

The rainfall pattern in Indonesia consists of three types (Boerema, 1938). The first type is a monsoon rainfall with a monthly rainfall peak in December. The second is a more localised rainfall pattern in the eastern equatorial part of the country with a monthly rainfall peak in July-August. The third rainfall type is an equatorial rainfall characterized by two monthly rainfall peaks, in March and in October.

The monsoon rainfall can be further categorized into two groups that are prevalent in southern Indonesia. While both groups indicate a clear distinction between a dry and a wet season throughout the year, the first shows a longer dry period (i.e., in the eastern Nusa Tenggara islands) and is drier overall compared to the second group (i.e., the western islands of Java, South Sumatra and South Sulawesi). The regions in the first group experience severe drought more frequently. Also, in general, rainfall variation is larger during the dry season (April to September) compared to the wet season (October to March).

The more localised rainfall pattern located mainly in the eastern equatorial part of Indonesia (e.g., Maluku and Sorong) results in wet seasons between April and September and dry seasons between October and March. The dry periods of this type of rainfall are not as severe as those of monsoonal types; as a result, the total rainfall in a given year is relatively high.

The third type of rainfall, equatorial, can be divided into two groups. The first group covers the west coast of North Sumatra with no pronounced dry season and with slightly increased rainfall around March and October. The second group covers the west coast of South Sumatra with uniform distribution of rainfall throughout the year.

Overall, these three types of rainfall result in a wet season that varies in length from as long as 280 to 300 days or as short as 10 to 110 days, with the rainfall during that season varying from 4,115 mm to as low as 640 mm. Rainfall variability in Indonesia is strongly affected by phenomena associated with ENSO (El Niño Southern Oscillation). The impact of ENSO on rainfall is more pronounced during the dry season than the wet season (USDA, 1984; Las et al., 1999). Various studies on ENSO influences on inter-annual rainfall variability in Indonesia reveal the following seasonal patterns (USDA, 1984; ADPC, 2000; Yoshino et al., 2000; and Kirono and Partridge, 2002): (i) the end of the dry season occurs later than normal during El Niño and earlier during La Niña years, (ii) the onset of the wet season is delayed during El Niño and advanced during La Niña years, (iii) a significant reduction of dry season rainfall could be expected during El Niño and a significant increase during La Niña years, (iv) long dry spells occur during the monsoon period, particularly in Eastern Indonesia. Moreover, as well as causing rainfall variation, the effect of ENSO itself is varied. ENSO effects are particularly strong in regions that are strongly influenced by monsoon systems, weaker in regions that are dominated by equatorial systems, and not traceable in regions driven by local weather systems (Tjasyono, 1997).

1.2 Extreme Climate Events

Extreme climate events in Indonesia are normally associated with ENSO. El Niño events are associated with drought and La Niña event are associated with heavy rainfall and flooding. Because the ENSO signal is very strong in the regions dominated by monsoonal rainfall (i.e., Java, Bali and Nusa Tenggara), extreme events are most pronounced in these areas. In these islands, for example, the decrease in dry season rainfall could be twice that of the other islands (Figure 1.2). Over recent years, El Niño events have become more frequent as the global temperature anomalies continue to increase (Hansen *et al.*, 2006). This indicates that the extreme regional weather and climate anomalies associated with El Niño are being exacerbated by increasingly higher temperatures. These warmer conditions have been linked to higher concentrations of atmospheric greenhouse gases (GHGs) (Timmermann et al. 1999; Collins 2000, b; Cubasch *et al*. 2001; Chen *et al*. 2005; Guilyardi 2005).

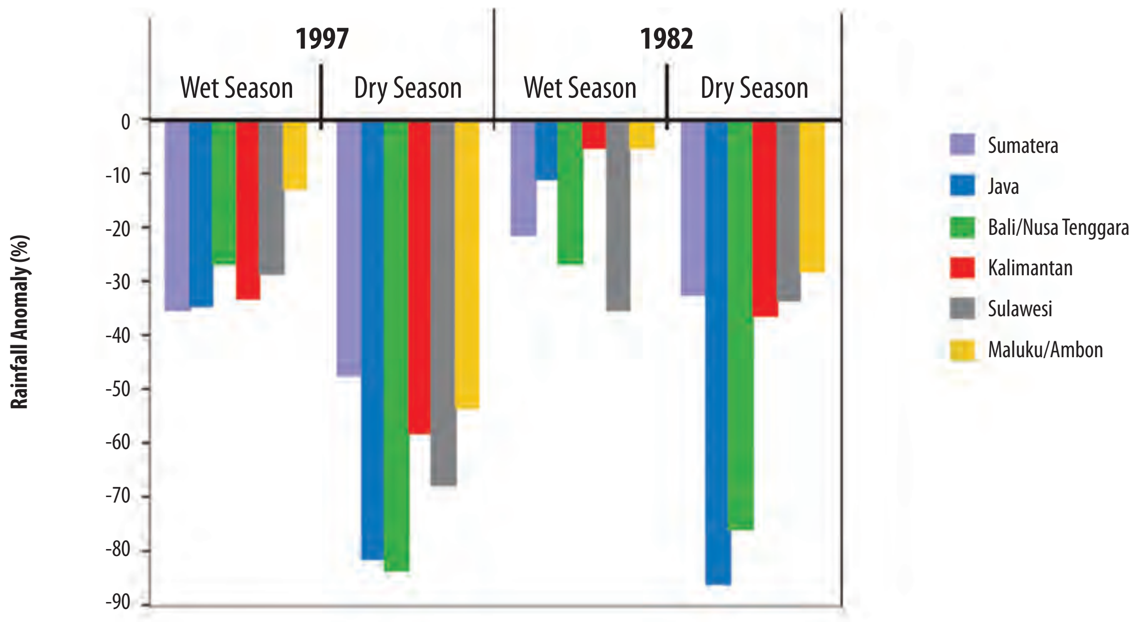


Figure 1.2 Percent decrease in seasonal rainfall from normal during two strong El Niño years, 1997 and 1982 (Irawan, 2002)

With the increasing frequency and intensity of extreme climate events, the most affected group will be the poor, as their adaptive capacity is most limited. If more vulnerable groups are exposed to repeated climate hazards, resilience will be more quickly compromised, making it increasingly more difficult to recover. In many cases, this is leading to high levels of unsecured and informal household debt. The Government of Indonesia also spends significant amounts of public funding in an effort to reduce vulnerability and improve resilience of poor populations. Based on data collected by the Office of U.S. Foreign Disaster Assistance/Center for Research on the Epidemiology of Disaster (OFDA/CRED) International Disaster Database (2007) from 1907 to 2007, it is clear that climate-related hazards are becoming increasingly more dominanct in the current decade (2000-2010). From the record, the number of natural hazards categorized as global hazards was 345 events; about 60% were climate-related hazards. The first climate hazards occurred in 1953 and they became more frequent after 1980s (Figure 1.3). The most frequent hazard was flooding, followed by landslides and water or vector-borne diseases, wind storms, forest fires, drought and high tide/storm surge.

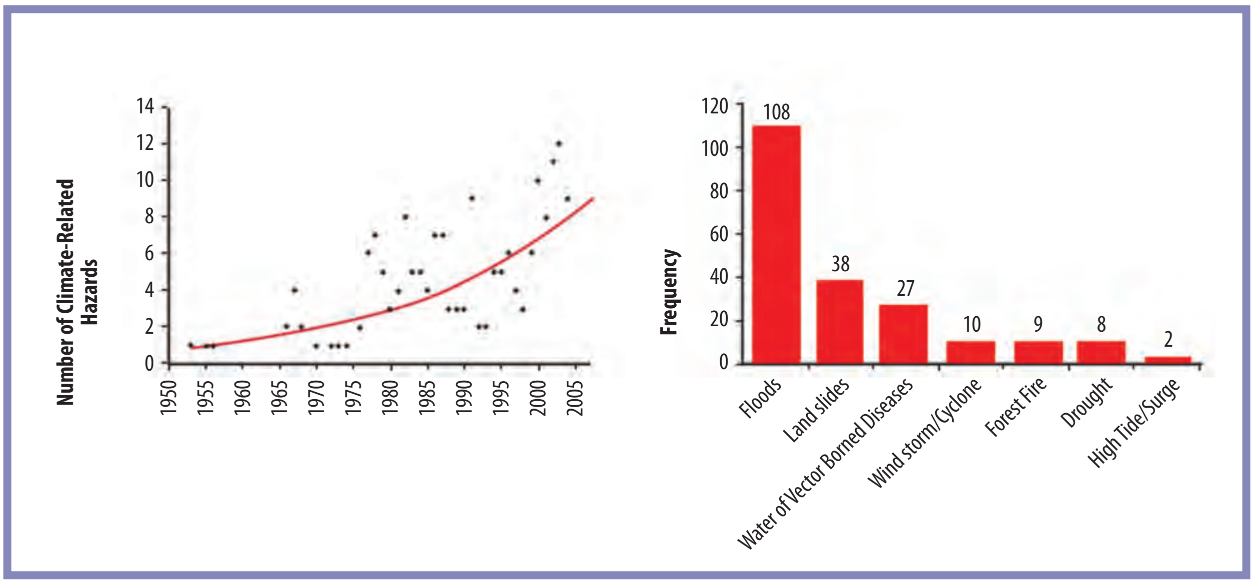


Figure 1.3 Number of climate hazards by type (left) and by year (right).
Source: Based on data from OFDA/CRED International Disaster Database (2007)

1.3 Economic and Social Development

Indonesia is the fourth most populous nation in the world following China, India and the United States. According to national statistics (Indonesian Bureau of Statistics – BPS 2005/2006), the total population of Indonesia in 1971 was 119 million, increasing to 230.3 millions in 2008. Currently, the population growth rate appears to be slowing from 1.49% (1990–2000) to 1.34% (2001–2005). Nevertheless, it is projected that Indonesia's population will exceed 300 million by 2030.

Life expectancy has improved from 41 years in 1990 to 65 years in 1997. However, adult illiteracy dropped 40% in just 37 years. Based on BPS data from 2005, the number of people living in urban areas totals approximately 44 million people (20% of the total population), while people living on coastal areas reaches roughly 20 million (9% of the total population). The majority of people living near the coast are poor, particularly in North Sumatra, parts of West and Central Java, and most of the islands in the eastern parts of Indonesia and Papua.

Indonesia had been experiencing marked improvements in its poverty rates until the economic crisis in 1999. Prior to 1999, Indonesia had been successful in its programme to alleviate poverty – in 1970, 60% of the population (70 million people) was living in absolute poverty; by 1990, the number had dropped to 27 million or 15% of the population and continued to improve to 1997, when the figure decreased to 20 million. However, in 1999, for the first time in years, Indonesia experienced a severe 18-month drop in the country's social condition, resulting in over 100 million people living below the poverty line.

As such, poverty remains a challenge. Unemployment and underemployment are also still relatively high. The Mid-Term National Development Plan (RPJMN) 2004–2009, it target for poverty and unemployment was 5.1% and 8.2%, respectively. A recent report from BPS stated that unemployment by February 2008 reached 8.46% or about 9.43 million people. However, based on the projection of the Institute for Development Economics and Finance (INDEF), due to current economic crisis, the number of poor and unemployed may have increased to 9.5% and 16.3%, respectively, in 2008 (Depsos, 2009).

Indonesia's gross domestic product (GDP) is approximately US$175 billion, with trade (16.7%), manufacturing (28%), agriculture (15.4%) and services (10.17%) as the main contributors. Earnings from exports (oil and gas, textiles, appliances, coal, copper) were approximately US$69 billion, while imports (food, chemicals, capitals and consumer goods) generated about US$44.8 billion. The GDP growth has increased steadily since 1998 and reached 6.3% in 2007 (Table 1.1). This has brought per capita GDP to around US$2000, which is considerably higher than the pre-crisis level (around US$1,000; Siregar, 2008). The role of non-oil and gas sectors has become more significant since the Asian Financial Crisis (AFC); the oil and gas sectors' contribution to the economy decreased, as indicated by the negative growth rates for the whole period, except in the year 2000. Among the non-oil and gas sectors, agriculture has played an important role. It is the sector least affected by the AFC and in fact helped the recovery of Indonesian economy after the crisis. This was due to its role as "the employer of last resort" and its substantial increases in exports (Siregar, 2008).

Table 1.1 Per capita GDP and growth rates of the economy, 1997-2007

Economic parameters	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Per capita GDP (USD)	1093	478	689	804	772	922	1098	1186	1318	1663	1946
GDP Growth	4.7	-13.1	0.8	4.9	3.6	4.5	4.8	5	5.7	5.5	6.3
Non-Oil & Gas GDP Growth (% per annum)	5.2	-14.2	1	5.3	4.9	5.2	5.7	6	6.6	6.1	6.9
Oil-Gas GDP Growth (% per annum)	-1	-0.5	-1.3	1	-5.3	-1.3	-2.9	-3.5	-3.1	-1.3	-0.8
Manufacturing GDP Growth (% per annum)	5.3	-11.4	3.9	6	3.3	5.3	5.3	6.4	4.6	4.6	4.7
Agriculture GDP Growth (% per annum)	1	-1.3	2.2	1.9	3.3	3.4	3.8	2.8	2.7	3.4	3.5

Source: (Based on BPS data; Siregar, 2008)

Success in pursuing macroeconomic stability over the past few years has been the primary factor in reducing poverty in Indonesia. However, economic growth alone is not sufficient for improving the well-being of the poor; additional efforts are still needed to address their needs. Indeed, the global financial crisis triggered by the U.S. sub-prime mortgage crisis caused some doubt about the continuation of post-AFC Indonesian economic growth. Gradual increases in commodity prices, especially in the agriculture sector, followed by abrupt decreases in 2009 have exacerbated uncertainties (Siregar, 2008). This may negatively affect efforts to further develop the commodities and related industries.

The current global financial crisis (GFC) is distinct from the AFC in 1997/98. In the case of the AFC, the significant rupiah depreciation was followed by increases in Indonesian exports, especially of agriculture, shortening the recession period. The current depreciation of rupiah following the GFC seems unlikely to be followed by similar increases in exports because the main export destinations around the world have also been adversely affected; the recession may thus last considerably longer (Siregar, 2008).

Despite positive macroeconomic achievements, the country still faces major challenges in a number of key areas, such as employment creation, improvement of the investment climate and ensuring that Indonesia fully benefits from its integration into the international trading system (European Community, 2005). Between the onset of the AFC in 1997 until 2006, unemployment had continuously increased in absolute as well as in percentage terms, reaching 11.1 million (10.4 percent) (Table 1.2). Although this has been reduced over the course of the last two years, the figures are still reasonably high, with 9.4 million people (8.5%) unemployed in February 2008. Due to the current GFC, the number of unemployed may continue to increase if the main sources of recovery and growth are capital-intensive sectors (Siregar, 2008).

Table 1.2 Labor force and open unemployment in Indonesia, 2000-2008

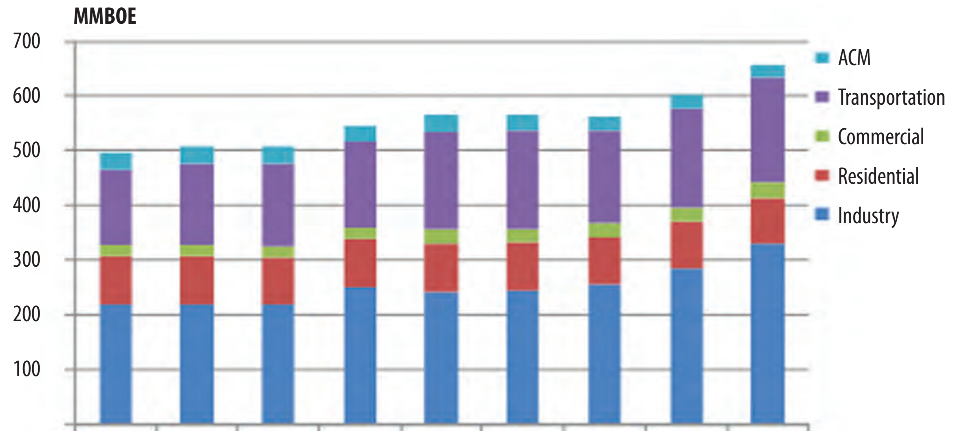
Year	Labor Force (Million people)	Open Unemployment (Million People)	Open Unemployment (% of total)
2000	95.65	5.81	6.08
2001	98.81	8.01	8.10
2002	100.78	9.13	9.06
2003	102.63	9.82	9.57
Aug-04	104.00	10.3	9.90
Feb-05	105.80	10.9	10.30
Feb-06	106.30	11.1	10.44
Feb-07	108.13	10.55	9.76
Feb-08	111.48	9.43	8.46

Source: (Based on BPS data; Siregar, 2008)

1.4 Sectoral Conditions

1.4.1 Energy Sector

Indonesian final energy consumption has been growing in line with the country's economic and population growth. According to the latest official published data from Data and Information Center (PUSDATIN) – MEMR (2009a): Indonesia Energy-Economic Handbook 2009, the domestic consumption of final energy (excluding biomass) in Indonesia grew from 495.45 MMBOE (million barrel oil equivalent) in 2000 to 564.94 MMBOE in 2005 (at average growth rate of 3.1 % per year). The majority of this consumption is accounted by industry sector, followed by transportation, residential, commercial, and ACM (agriculture, construction, and mining) sectors (see Figure 1.4). In 2008, the final consumption is about 658.36 MMBOE. The share of total energy consumption by sector in 2008 is industrial sector 48%, transportation 31%, household 13%, commercial 4%, and ACM 5 % (Table 1.3).



	2000	2001	2002	2003	2004	2005	2006	2007	2008
ACM	29.21	30.59	30.00	28.45	31.69	29.10	25.94	24.91	24.84
Transportation	139.1	148.2	151.5	156.2	178.3	178.4	170.1	179.1	191.2
Commercial	19.22	20.01	20.32	20.97	23.99	24.82	24.79	26.49	27.62
Residential	87.96	89.02	86.57	88.67	90.69	89.07	84.53	87.72	84.56
Industry	219.8	219.7	218.6	249.9	241.0	243.5	257.3	283.4	330.0

Figure 1.4 Final energy consumption in Indonesia, 2000 – 2007 [MEMR, 2009]

Table 1.3 Type of final energy consumption by sector, 2008 MMBOE [MEMR, 2009]

Sector	Oil Products	LPG	Natural Gas	Coal	Electricity	Total	%
Industri	49	1	89	160	29	328	48
Transportation	191	-	0	-	0	191	31
Household	40	14	0	-	31	85	13
Commercial	7	1	0	-	19	28	4
Others	25	-	-	-	-	25	5
Total	312	16	90	160	79	657	100

Source: Indonesian Energy Outlook 2009, Data and Information Center, MEMR

Indonesia is endowed with varous type of energy reources, fossil energy resources as well as new and renewable energy resources. As an overview, among of the fossil resources, coal has the longest reserves to production ratio, i.e. 82 years, while new and renewable resources are also potential. The utlization level of the new and renewable resources, however, is still low. This indicate that these resources could be futher developed to supply future energy demand. The distrubution of location of each resource and the coresponding infrastucture of the reources (mostly outside Java) are miss matched with energy demand center (mostly Java). Therefore, the development of energy resources in Indonesia considers this situation.

To supply the domestic energy demand, Indonesia uses different types primary energy sources, i.e. oil, natural gas, coal, hydro, geothermal, and biomass. Among these primary energy sources, the dominant energy source is fossil fuels. As an overview, the primary energy supply mix (excluding biomass) in 2005: oil (48.5%), natural gas (27.1%), coal (18.7%), hydro (3.4%) and geothermal (2.3%). In terms of annual average growth during 2000 - 2005, coal outpaced other fuels: coal 14.3%, oil 2.6%, and gas 0.6%. According to the Indonesian National Energy Policy (Presidential Regulation No.5/2006), it is projected that coal, natural gas, and renewable energy will replace oil in the future so that in 2025 the primary energy supply mix will become: coal 33%, natural gas 30%, oil 20%, and renewable and other new energy 17%. It should be noted that the primary consideration in targeting the energy supply mix is energy security concerns.

Concerning the biomass energy, it is primarily consumed in rural residential and agro industries. During 2000 – 2005, the biomass consumption is relatively constant, in the order of 270 MMBOE per annum. A relatively small fraction (± 15%) of the biomass is used in industrial captive power and heat generations, i.e. in pulp paper industry, wood processing, and palm oil mills. With regard to power sector, the primary energy supply is dominated by coal, followed by natural gas and oil. As an overview, energy mix in the power sector in 2005: coal (40.4%), oil (26.2%), hydro (13.3%), natural gas (11.2%), geothermal (8.9%).

Elasticity of energy in Indonesia is relatively high compared to other countries (1.84 compared to around 1.0). This implies that more energy is needed by Indonesia to increase per unit of GDP. One of national energy policy objectives is to reduce elasticity to less than 1 by 2025. The objective can largely be achieved through energy efficiency and the national policy of energy efficiency (EE) is already established. This policy is also supported by EE programmes and measures.

1.4.2 Industrial Sector

The growth of Industrial sector, particularly for mineral, chemical and metal products in the period of 2000-2005 was quite slow and even negative for some industries (Table 1.4). Since 1998, after the global economic crisis, investment on these types of industries has been very limited. It is estimated that until 2025 these types of industries may not grow.

Table 1.4. Growth and production of industrial products (000 ton) in the period 2000-2005

Year	2000	2001	2002	2003	2004	2005	Growth (%/yr)
				Mineral Products			
Cement production	27,800.00	31,100.00	31,360.00	30,600.00	33,000.00	33,920.00	3.26
Clinker Export	3,552.00	3,707.00	3,791.00	4,270.00	4,680.00	3,407.24	-0.62
Lime production	4,917.53	9,382.15	2,770.10	2,744.89	2,820.01	2,827.93	-8.21
Glass production	1,700.00	1,301.71	1,435.26	1,342.25	1,460.50	1,499.85	-2.29
Ceramic Production	13.32	2.16	2.16	4.43	1.31	0.50	-53.68
				Chemical products			
Ammonia production	4,785.00	4,406.80	4,771.42	4,860.41	4,546.26	5,125.31	1.19
HNO3 production	23.04	13.77	14.99	14.99	14.99	14.99	-8.32
Silicon Carbide	27.40	18.13	19.73	19.73	19.73	19.73	-6.16
Calcium Carbide	22.45	70.17	76.40	76.40	20.23	20.23	-0.78
CaC2 in Asetilena Production	19.02	19.02	12.10	11.64	12.89	12.83	-7.07
Methanol	794.47	931.36	785.03	792.33	787.91	845.54	1.03
Ethylene	499.32	397.58	428.27	476.28	465.05	487.22	-0.44
Ethylene Dichloride	760.95	787.89	782.03	798.91	799.99	727.99	-0.71
Carbon Black	94.52	98.18	90.83	95.65	110.00	123.00	4.65
				Metal Products			
Basic Oxygen Furnance	27.40	18.13	19.73	19.73	19.73	19.73	-6.16
Pig Iron	0.29	0.23	2.40	3.21	2.63	33.03	78.36
Sinter	1,355.69	1,917.86	859.42	2,211.91	2,425.27	2,269.83	8.28
Al production	240.00	240.00	240.00	240.00	240.00	240.00	0.00
PFC	0.07	0.07	0.07	0.07	0.07	0.07	0.00
Lead Production	27.40	18.13	19.73	19.73	19.73	19.73	-6.16
Zinc Production	71.87	98.74	55.28	56.62	40.97	61.82	-2.61

Source: BPS (2007)

1.4.3 Forestry Sector

In Indonesia, the state land is divided into two areas: forest area and non-forest area. Forest area is not always covered by forest. Similarly, non-forest area does not necessarily mean it has no forest. Non-forest area is commonly referred to as "area for other uses" (i.e., non-forest activities such as for agriculture plantation, settlement, road etc.; abbreviated as APL). Total forest area is approximately 133.6 million ha and non-forest area is 54.3 million ha (Baplan, 2008). Based on its function, about 15% of forest area is categorized as conservation forest (HK), 22% as protection forest (HL), 46% as production forest (HP) and 17% as convertible production forest (HPK). This convertible production forest can be released as APL in the future. Based on 2007 satellite assessments, forest area covered by forest was about 85.9 million ha (64%), 39.1 million ha were without forest and 8.5 million ha were unidentified due to cloud cover (BAPLAN, 2008).

In non-forest area (APL), the forested land was estimated to be about 7.96 million ha (15%; Table 1.5).

Table 1.5 Forested and non-forested land in forest and non-forest area in 2007 (thousand ha)

	Forest Area (x 000 ha)				APL
	HK	HL	HP	HPK	
Forested land	14,365	22,102	38,805	10,693	7,960
Non-forested land	4,009	5,622	18,404	11,057	44,163
Unidentified	1,502	2,328	3,706	981	2,216
Total	**19,876**	**30,052**	**60,915**	**22,732**	**54,339**

Source: Baplan (2008)

From satellite interpretation, rate of forest loss between 2000 and 2005 reached about 1.1 million ha per year (BAPLAN, 2008). Most of deforestation mainly occurred in HP and the followed by APL, HPK, HK and HL (Figure 1.5; MoF 2008). The rate of deforestation is expected to increase in the future, particularly in open access forest areas. Open access area is defined as forest areas that have not been granted to concessionaires and have no on-site agencies responsible for managing the areas. At present only conservation forests have on-site management agency (called as National Park Agencies). In one of its priority policies, the Ministry of Forestry will establish a Forest Management Unit (FMU) in all forest areas. Thus, all forest areas in the country will have on-site management unit. It is estimated that the number of FMU needed for all over Indonesia is about 700 units. With the current budget, the Government of Indonesia is only able to establish about 210 FMUs in the next 15 years. The establishment of FMU will therefore be prioritized in regions with high deforestation risk.

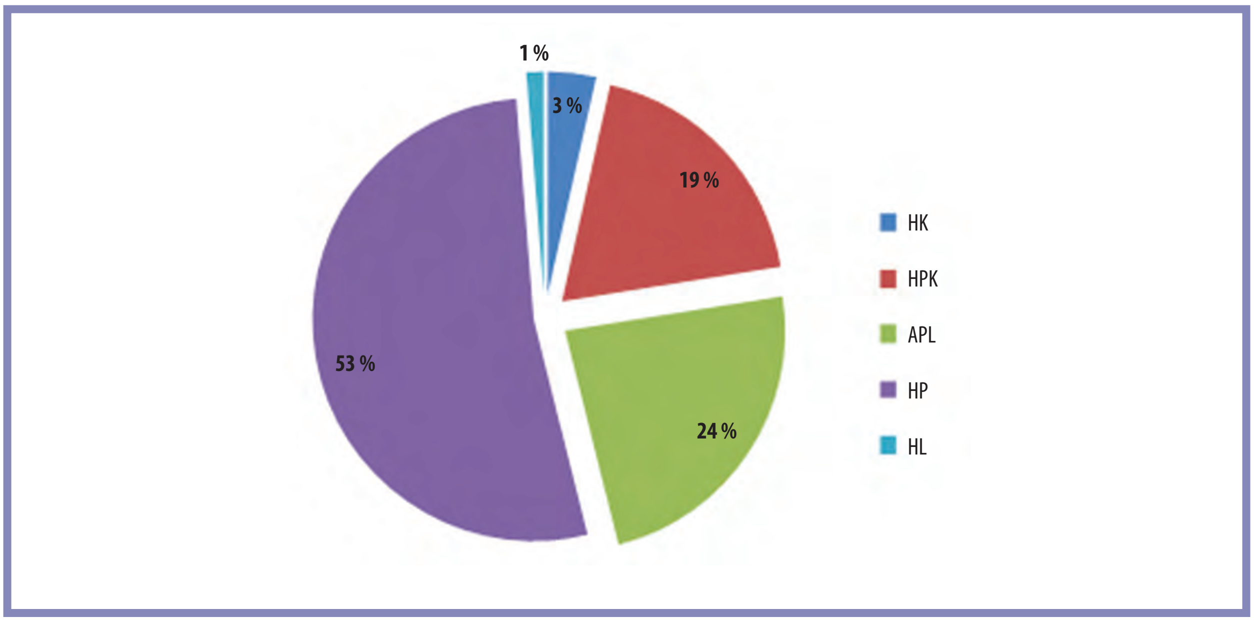


Figure 1.5 Fraction of forest loss in forest area and non-forest area

There are many factors causing deforestation and forest degradation in Indonesia. They in-clude (i) forest fire, (ii) illegal logging, (iii) forest encroachment, (iv) forest conversion for establishment of agriculture plantation, transmigration areas, and establishment of new dis-tricts, (v) development of new rice fields, and (vi) large-scale mining activities. The first three factors are defined as unplanned deforestation and the remaining factors are defined as plan-ned deforestation. To reduce the rate of unplanned deforestation and forest degradation, and reduce the area of degraded land and forest, the In Government of Indonesia has established five priority policies as follows: (i) combating illegal logging and forest fire, (ii) restructuring forestry sector industries, including enhancement of plantation development, (iii) forest rehabilitation and conservation, (iv) promoting sustainable forest area, and (v) strengthening economies of local communities. Implementation of these policies has reduced the rate of deforestation quite significantly (Figure 1.6). However, since a decentralized governance system is implemented, the desire to bloom and to form new autonomous regions is nearly unstoppable. From 2007 to 2008, approximately 43 new districts have been formed under the law (http://www.setneg.go.id/). In addition, several district-level governments have requested the to release forest area for expanding the area of their districts. This planned deforestation may become a big threat for the future of Indonesian forest areas.

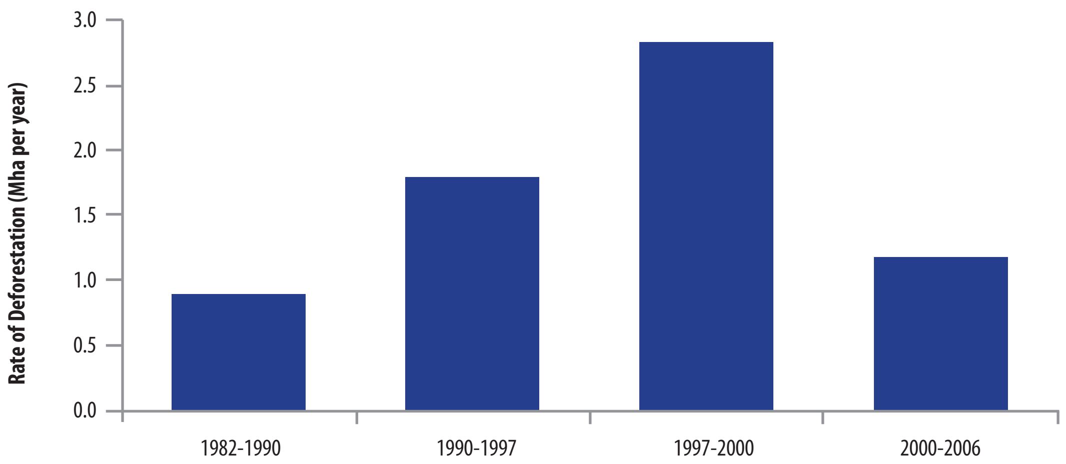


Figure 1.6 Rate of deforestation in Indonesia (MoF, 2007)

1.4.4 Agriculture Sector

During the period from 2005-2009, agricultural development continued to record varying success. One notable success was that Indonesia achieved rice self-sufficiency since 2008, and self-sufficiency in maize consumption of households occurred in 2008. Stable production of rice, which is the main food is helping to stabilize domestic food prices, so that Indonesia can avoid a food crisis that struck many countries during this period. However, the long-term trend indicates a steady decline in sawah (paddy field) area, as much as 14,000 ha annually (Figure 1.7). This is primarily due to conversions of paddy field to urban and settlement developments (Agus *et al.* 2006). If this continues, rice self-sufficiency will not sustain. On the other hand, plantation area has drastically increased at a rate of 571,000 ha annually. The areas of annual upland and idle lands (including Imperata grass and bush lands) fluctuate, but there is an increasing trend for these two land use systems over the last six years. The increase in plantation, upland farming and idle lands postulates a decreasing forest area.

Rapid increase in the area of agriculture plantation is mainly due to the high growth of palm oil plantation. The area of palm oil increased exponentially over the last two decades (Figure 1.10). Between 1994 and 2008, the average increase was 12.3% annually from about 0.6 to 6.6 million ha. The rapid increase in the palm oil plantations is driven by the demand increase in the domestic and international markets, including the demand for bio-diesel. Areas of cacao and coffee plantation have also increased, but not as drastically as that for palm oil.

To increase the production of main agriculture commodities, particularly rice and palm oil, Indonesia has targeted to expand the palm oil plantation as much as 1.375 million ha between 2010 and 2015 (DG of Estate Crop, 2008). The target provinces for the establishment of palm oil plantations are East, West and Central Kalimantan, Jambi and South Sumatra. These five provinces account for 78% of the total area. To secure rice production in the future, Indonesia also plans to have 15 million ha of land permanently allocated for cropland. At present, the total area of paddy field (sawah) is approximately 7.8 million ha; thus, an additional 7.2 million ha is needed to meet this target. Based on Ministry of Agriculture estimate (IAARD, 2007), total suitable area for sawah is 8.3 million ha in which 3 million ha is swamp land (including mineral wetland and peatland) and the other 5.3 million ha is convertible upland. However, the area of potential suitable land changes rapidly because of competition in land uses for housing and urban developments. Thus, the currently available lands for sawah may be less (Agus *et al.* 2006).

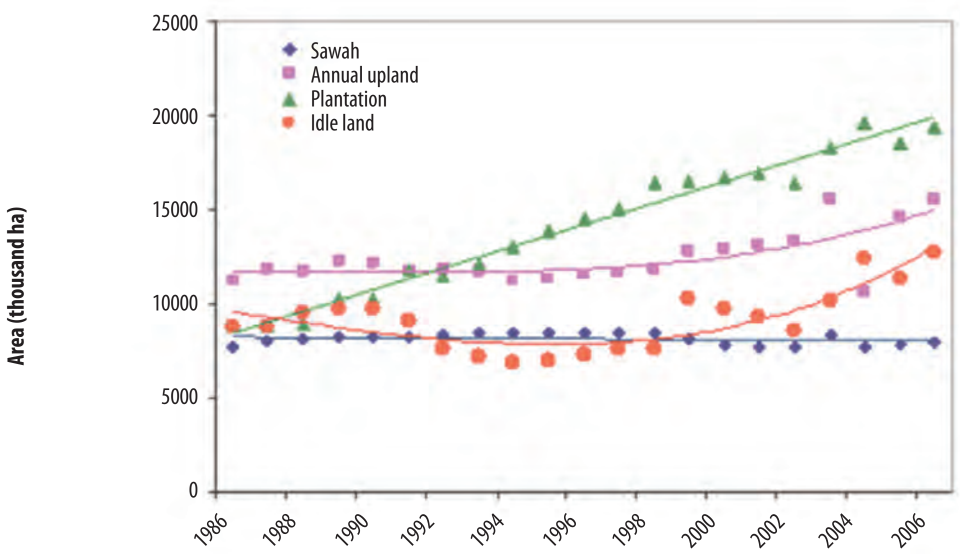


Figure 1.7 Development of the main agricultural systems from 1986 to 2006 (Data taken from Central Bureau of Statistics)

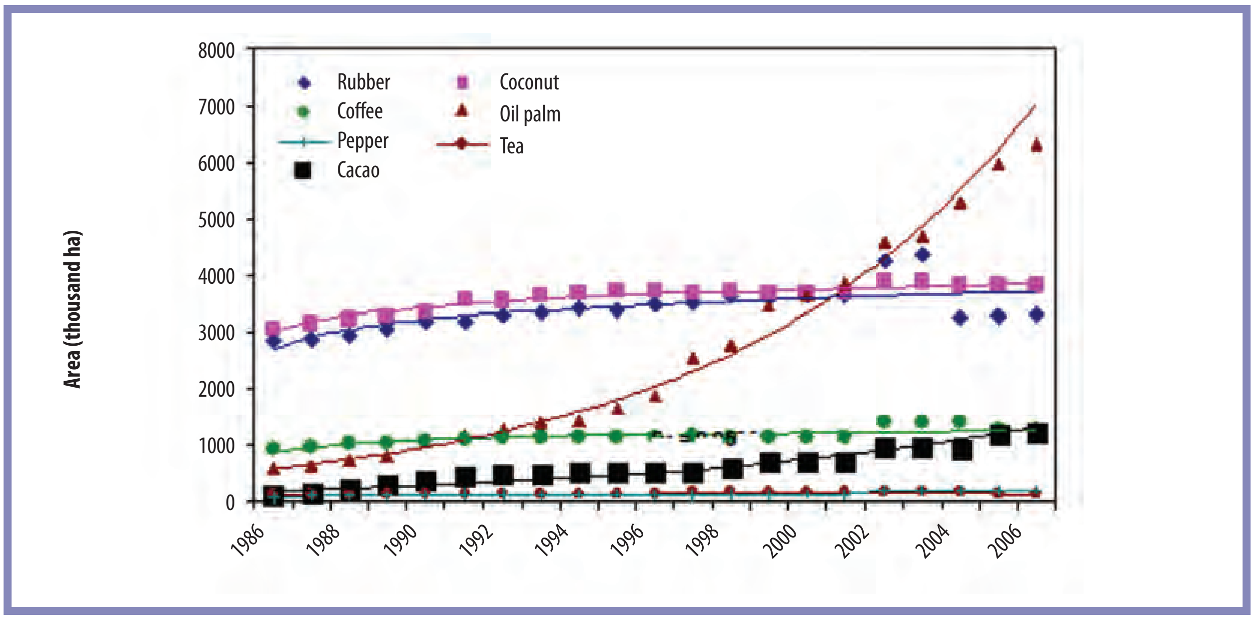


Figure 1.8 Development of the main plantation areas from 1986 to 2006 (Data taken from Central Bureau of Statistics)

1.4.5 Water Sector

In general, the Indonesian territory has 6% of the world's fresh water reserve or approximately 21% of water reserve in the Asia-Pacific region. The availability of water in Indonesia is quite high as indicated by the high level of rainfall and the potential availability of surface water and groundwater. However, many areas in Indonesia have suffered from difficulties of usable water availability in recent years. Java (with its high population and high industrial activities), Bali and East Nusa Tenggara already have water deficits (Directorate General of Water Resource, 2007). The total water demands of the country are currently for supporting irrigation, domestic, and municipal and industrial usages of 1,074 m3/sec; however, the low flow available during a normal climatic year are only about 790 m3/sec or approximately 76% of the total water demand. This deficit will increase as population and economic activities increase.

There are a number of factors causing the reduction of water quantity and quality in Indonesia. The first factor is the degradation of the carrying capacity of upstream areas of water catchments as a result of the uncontrolled clearing of forests. This is has been indicated by the increase in the number of critical catchments areas of river basins from 22 river basins in 1984 to 39 river basins in 1992 and an increase to 62 catchment areas in 1998 (MoE, 2007). The second factor is uncontrolled land clearing within flooding areas, water catchment areas and riverbanks that has resulted in reduced infiltration capacity, changes in river morphology, and reduced carrying capacity of the streams, thus expanding the risk and increasing the frequency of flooding. The third factor is the uncontrolled abstraction of water that also causes increased saltwater intrusion and land subsidence. The fourth factor is the degradation of riverbeds in Java, Bali and West Nusa Tenggara due to exploitation of sand that causes infrastructure and structural damage along rivers. The fifth and final factor is the increased sedimentation of riverbeds resulting from household solid waste disposal and mining.

Efforts for managing water resources have been carried out by the Government through instrumentation of regulation and programs executed by related sectors. In general, the efforts focused into two activities: the conservation of water and control of water pollution.

1.4.6 Coastal and Marine Sector

Indonesia is an archipelago state that has approximately 5.8 million km^2 of ocean area and 81,000 km coastline (the longest coastline in the world), with more than 17,500 islands. Coastal areas, small islands, marine life and fisheries play an important role in supplying food energy, supporting natural cycles, and regulating the global climate. From an economic standpoint, Indonesia's fishery resources equate to 6.65 million ton per annum that consist of 4.35 million ton in territorial and 2.3 ton in the Executive Economic Zone (MoE, 2007). About 140 million people or 60% of the total population lives within 50 km of the shoreline, spread across 42 cities and 182 districts.

Indonesia is also regarded as one of the world's mega centers of biodiversity for its extraordinarily high levels of diversity; each coral reef area containing at least 2,500 species of fish, although, at present, but only 30% of these reefs are in good or excellent condition. Due to the richness of these reef areas, the coastal zone policy and management decisions made by the country will have a major impact on the global heritage of coral reef diversity (Bryant et al., 1998).

However, in several areas the oceans have been damaged due to non-environmentally friendly practices. The coral reef damage level in Indonesia reached 40% - 24% of all reefs are considered to be in damaged and medium damaged condition with only 6% remaining in very good condition. It has been estimated that 90% of Indonesia's coral reefs have been damaged by a combination of non-environmentally friendly fish-catching practices, over-fishing, sedimentation and land-based pollution, and coral mining (MoE, 2007).

Similar conditions are also observed in Indonesia's mangrove ecosystems. In 1993, Indonesia's mangrove forest was noted to have an area of 3.7 million ha, dispersed throughout the Indonesian coast, starting from the Island of Sumatra, Kalimantan, Java, Sulawesi, West Nusa Tenggara, East Nusa Tenggara, all of Maluku Islands, and in Papua. However, in 2005, the remaining mangrove forest was only 1.5 million ha. The mangrove forest has significantly decreased between 2% (the lowest) in East Java and 100% (the highest) in East Nusa Tenggara. The causes of disappearance of mangrove forests are the illegal cutting of mangrove wood, area clearing for shrimp breeding and also wet and dry farms (MoE, 2007).

Sea grasses are common throughout the tropical and temperate coastal waters of the Asia and Pacific Region. The Center for Oceanography Research of the Indonesian Institute of Science (LIPI) reported that 12 species of seagrass lived in Indonesia's waters in 2006 (MoE, 2007). However, 20-25% of seagrass areas in Indonesia have been damaged by a combination of coastal development, elevated sedimentation levels, destructive fishing methods and land-based pollution, thermal discharge, petroleum product spills, and dredge and fill operations.

Many initiatives are already carried by the Government and environmental non-governmental organizations (NGOs) related to coastal and marine management such as the Coral Reef Rehabilitation and Management Program (COREMAP) program, including mapping priority areas for rehabilitation and utilization in marine and coastal areas, and mangrove rehabilitation management as well as the Coral Triangle Initiative. This initiative conserves a marine region that spans those parts of Indonesia, Malaysia, New Gunea, the Philippines, the Solomon Islands, and Timor Leste with at least 500 species of reef-building corals; provides incomes and food security more than 120 million people living in this area.

CHAPTER II
National GHG Inventory

2.1 Introduction

The Indonesian National Greenhouse Gas Inventory (NGHGI) includes estimates of emissions by source and sink for the period 2000-2005. It was drawn up in line with Articles 4 and 12 of the United Nations Framework Convention on Climate Change (UNFCCC) and the Guidelines for National Communications of non-Annex I Parties of the UNFCCC, adopted in decision 17/CP.8, which state that non-Annex I Parties should include information in a national inventory of anthropogenic emissions by source and absorption by sinks of all greenhouse gases (GHGs) not controlled by the Montreal Protocol, within the limits of their possibilities, using the methodologies promoted and approved by the Conference of Parties (COP).

The calculations of GHG emissions reported in the Second National Communication (SNC) were made for the six emissions categories defined by the Intergovernmental Panel on Climate Change (IPCC): Energy, Industrial Processes, Solvents, Agriculture, Land Use Change and Forestry and Waste. The NGHGI 2000-2005 reports on the three main GHGs included in Appendix A of the Kyoto Protocol: carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). Some information is also included on three other minor gases (CO, NO_X and perfluorocarbons [PFC]). The emissions estimates for each emissions category were created thanks to the dedicated work of specialists from the Ministry of Energy and Mineral Resources, the Ministry of Transportation, the Ministry of Forestry, the Ministry of Agriculture, the Ministry of Environment, Bandung Institute of Technology and Bogor Agriculture University.

2.2 Institutional Arrangements

The development of the NGHGI was conducted by the Working Group on Inventory assisted by experts and a technical team from two universities (Bandung Institute of Technology and Bogor Agriculture University), as well as two research agencies (Forest Research and Development Agency and the Indonesian Agency for Agriculture Research and Development). The members of the working group came from various government institutions concerned with energy and mining, industry, transportation, waste, agriculture and forestry. The working group was officially recognized through the Environment Minister Decree and worked under the coordination of the Deputy of Nature Conservation Enhancement & Environmental Destruction Control of the Ministry of Environment (Figure 2.1).

2.3 Description of the Process of Preparing the Inventory

Preparation of the NGHGI 2000-2005 was carried out in five phases: (1) beginning, (2) development, 3) sectoral consultation, 4) writing up the report and external review and 5) revision and publication, as outlined below:

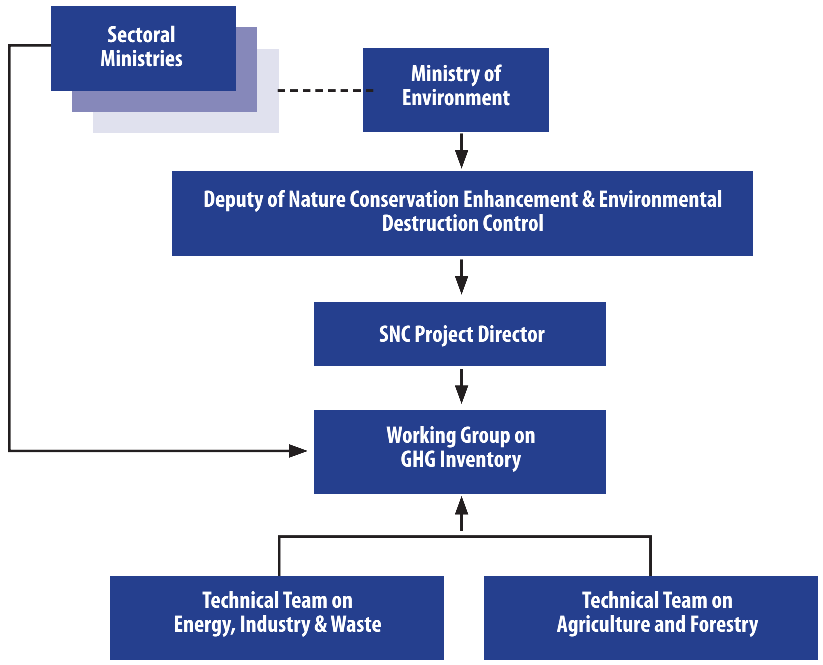


Figure 2.1 Structure of the institutional arrangements for developing NGHGI 2000-2005

1. Beginning: In this phase, a meeting of the working group and inventory experts was called to discuss the methodologies and good practices to follow in the preparation of the Inventory. During this phase, the type of activity data and emissions factors required for the Inventory were identified. The Coordinator of the Working Group through the Ministry of Environment officially requested the activity data for each sector and the experts collected this data, as well as the emissions/removal factors from various publications and research agencies.

2. Development: After activity data and emissions/removal factors were gathered for each emissions category or sector, the data and information obtained were recorded on spreadsheets. Emissions were then estimated and a report was prepared by the experts; this included the emissions estimates, as well as the analysis carried out and the sources of information consulted. During this phase, coordinators of the working group followed up with requests for information made by the experts and were given support in obtaining additional data that was necessary for further estimates.

3. Sectoral Consultation. After the experts completed the Inventory, the results were discussed with the members of the working group to check the estimates, activity data consistency and emissions/removal factors. Through discussion with external experts from different sectors, the levels of uncertainty inactivity data and emission factors were determined. Emissions trends were estimated by emissions category and by gas, and both general and category uncertainties were estimated.

4. Writing up the Report and External Review. After the consultation with sectors, the final inventory report was made up according to the format by the inventory experts. International experts through the United Nations Development Programme (UNDP) Country Office reviewed the reports, along with all spreadsheets of the inventory for all sectors. Inputs and comments from the external reviewers were used for the improvement of the inventory.

5. Revision and Publication. After the completion, the Ministry of Environment submitted the report to relevant ministries for final approval. The final adjustments and corrections were made to the document if errors were found.

2.4 Overview of Source and Sink Category Emission Estimates for year 2000

Methodology. From the Beginning Phase, the working group and the experts decided to adopt the 2006 IPCC Guidelines (GL) using Tier 1 and Tier 2 even though the adoption of this methodology was not in line with the Guidelines for National Communications of non-Annex I Parties of the UNFCCC, adopted in decision 17/ CP.8. The UNFCCC Guidelines stated that the non-Annex 1 countries used the revised 1996 IPCC GL for developing their inventory. The adoption of the 2006 IPCC GL was considered for some sectors as it covers some sources which are not included in the revised 1996 IPCC GL. Most sectors used Tier 1, and to some extent sectors adopted Tier 2 where local emissions/removal factors were used.

National Emissions. In 2000, total GHG emissions for the three main greenhouse gases (CO2, CH_4 and N_2O) without land use, land use change and forestry (LULUCF) and peat fires reached 556,499 Gg CO_2e. With the inclusion of LULUCF, total GHG emissions from Indonesia increase significantly to about 1,205,753 Gg CO_2e (Table 2.1). The GHG emissions (in CO2 equivalent) were distributed unevenly between the three gases recorded: CO_2 totalled 940,879 Gg, representing 78% of the total; methane (CH_4) totalled 236,388 Gg (CO_2e), or 20% of the total; and nitrous oxide (N_2O) totalled 28,341 Gg (CO_2e), or 2% of the total. The main contributing sectors were Land Use Change and Forestry, followed by energy, peat fire-related emissions, waste, agriculture and industry (Figure 2.2).

The emissions estimates in the SNC are lower than those reported by a 2007 study by Pelangi Energi Abdi Citra Enviro (PEACE), World Bank and the United Kingdom Department for International Development (DFID), which suggested Indonesia to be the third largest emitting country globally. The study estimated that the total emissions from Indonesia were approximately 3,014,000 Gg CO_2, where LUCF contributed about 85% or 2,563,000 Gg CO_2 (twice the SNC estimate above). Indeed, a later study from the World Bank in 2008 suggested that the mean annual CO_2 emissions from LUCF reached up to 2,398,000 Gg, assuming 53% from peat fire, 20% from peat drainage (peat oxidation), 22% from deforestation and 5% from palm oil and timber plantation establishment. Between the SNC and World Bank estimates, a recent study from the National Committee on Climate Change in 2009 suggested that the total GHG emissions from LUCF in 2005 reached 1,880,000 Gg CO_2e, where approximately 55% was from peat emissions (DNPI, 2009). These large differences in Indonesian emissions estimates thus appear to be mainly due to differences in estimates of LUCF emissions, particularly from peat.

Table 2.1a Summary of national GHG emissions in 2000

No	Source and sink Categories	CO_2 removal (Gg)	CO_2 emission (Gg)	CH_4 (Gg)	N_2O (Gg)	CO (Gg)	NO_x (Gg)	NMVOC (Gg)	SO_x (Gg)
	Total National Emission and Removals	**-296,794.38**	**1,352,471.68**	**11,256.59**	**91.42**	**2,335.71**	**85.66**	**NE**	**NE**
	1. Energy (without Biomass)		**247,522.25**	**1,436.89**	**10.45**	**NE**	**NE**	**NE**	**NE**
A	**Fuel Combustion Activity**		**240,876.89**	**455.51**	**10.40**	**NE**	**NE**	**NE**	**NE**
1	Energy production (electricity, heat, oil & gas refining)		84,011.42	1.89	0.64	NE	NE	NE	NE
2	Manufacturing Industries and Construction		63,032.48	7.39	1.10	NE	NE	NE	NE
3	Transportation		55,689.23	14.32	2.68	NE	NE	NE	NE
4	Commercial/Intstitutional		3,320.84	2.14	0.03	NE	NE	NE	NE
5	Residential		23,878.82	428.26	5.86	NE	NE	NE	NE
6	Non Specified		10,944.09	1.50	0.09	NE	NE	NE	NE
B.	**Fugitive Emissions**		**6,645.36**	**981.38**	**0.05**	**NE**	**NE**	**NE**	**NE**
1	Solid Fuels			17.22		NE	NE	NE	NE
2	Oil and Natural Gas		6,645.36	964.17	0.05	NE	NE	NE	NE
	2. Industrial Processes and Product Use		**40,342.41**	**104.44**	**0.43**	NE	NE	NE	NE
	A. Mineral		**28,923.82**			NE	NE	NE	NE
1	Cement Production		25,006.12			NE	NE	NE	NE
2	Lime Production		3,688.15			NE	NE	NE	NE
3	Glass Production		170.00			NE	NE	NE	NE
4	Other Process Uses of Carbonates		59.55			NE	NE	NE	NE
	B. Chemical		**9,938.97**	**9.54**	**0.43**	**NE**	**NE**	**NE**	**NE**
1	Ammonia Production		8,092.32	NE	NE	NE	NE	NE	NE
2	Nitric Acid Production		NE	NE	0.21	NE	NE	NE	NE
3	Caprolactam, Glyoxal and Glyoxylic Acid		NE	NE	0.22	NE	NE	NE	NE
4	Carbide Production		21.02	0.32		NE	NE	NE	NE
5	Petrochemical and Carbon Black Production								
	- Methanol		305.87	1.83	NE	NE	NE	NE	NE
	- Ethylene		1,122.97	1.50	NE	NE	NE	NE	NE
	- Ethylene Dichloride		149.15	0.23	NE	NE	NE	NE	NE
	- Carbon Black		247.64	5.67	NE	NE	NE	NE	NE
	C. Metal		**1,152.98**	**94.90**	**NE**	**NE**	**NE**	**NE**	**NE**
1	Iron and Steel Production		623.91	94.90	NE	NE	NE	NE	NE
2	Ferroalloys Production		2.39	NE	NE	NE	NE	NE	NE
3	Alumunium Production		384.00	NE	NE	NE	NE	NE	NE
4	Lead Production		19.05	NE	NE	NE	NE	NE	NE
5	Zinc Production		123.62	NE	NE	NE	NE	NE	NE
	D. Others		**326.65**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**
1	Lubricant Use		307.07	NE	NE	NE	NE	NE	NE
2	Paraffin Wax Use		19.57	NE	NE	NE	NE	NE	NE
	3. Solvent and Other Product Use		NE		NE			NE	
	4. Agriculture		**2,178.30**	**2,419.06**	**72.39**	**2,294.68**	**84.67**		
A	Enteric Fermentation			607.89					
B	Manure Management			79.69					

No	Source and sink Categories	CO_2 removal (Gg)	CO_2 emission (Gg)	CH_4 (Gg)	N_2O (Gg)	CO (Gg)	NO_x (Gg)	NMVOC (Gg)	SO_x (Gg)
C	Rice Cultivation			1,660.03	NE				
D	Agriculture Soils			NE					
1	Direct N_2O Soils			NE	50.11				
2	Indirect N_2O Soils			NE	18.34				
3	Direct N_2O from manure			NE	0.40				
4	Indirect N_2O from manure			NE	0.11				
E	Prescribed Burning of Savanna/grassland			24.05	2.20	679.78	40.79		
F	Prescribed Burning of Agriculture Residues			47.39	1.23	1,614.90	43.88		
G	Others								
1	Liming		218.02	NO	NE	NO	NO	NO	NO
2	Urea Fertilization		1,960.28	NO	IE	NO	NO	NO	NO
5. Land Use Change and Foresty		**-296,794.38**	**1,232,766.22**	**2.68**	**0.08**	**41.04**	**0.99**		
A	Changes in forest and other woody biomass stocks	-215,154.48							
B	Forest and grassland conversion		729,655.23	NE	NE	NE	NE		
C	Abandonment of croplands, pastures, plantation forests, or other managed lands	-81,639.89							
D	CO_2 emissions and removals from soils	NE	216,312.51						
E	Others:								
	- Forest Burning			2.68	0.08	41.04	0.99		
	- Peat Fire*		172,000.00	NE	NE	NE	NE		
6. Waste			**1,662.49**	**7,293.52**	**8.07**	**NE**	**NE**		
A1	Unmanaged Waste Disposal Sites		NE	612.83	NE	NE	NE	NE	
A2	Unmanaged Dumpsite		NE	249.72	NE	NE	NE	NE	
B	Biological Treatment of Solid Waste		NE	4.42	0.33	NE	NE	NE	NE
C	Open Burning Waste		1,662.49	62.34	1.44	NE	NE	NE	NE
D1	Domestic Wastewater Treatment and Discharge			459.59	6.30	NE	NE	NE	
D2	Industrial Wastewater Treatment and Discharge			5,904.63	NE	NE	NE	NE	
7. Others			**176,765.69**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**
	Inernational bunkers		NE	NE	NE	NE	NE	NE	NE
	Aviation		NE	NE	NE	NE	NE	NE	NE
	Marine		NE	NE	NE	NE	NE	NE	NE
	Biomass		176,765.69						

Note: * Emissions from peat fire are from van der Warf *et al*. (2007). Shaded cells do not require entries. NO: Not Occurring; NE: Not estimated; NA: Not Applicable; IE: Including Elsewhere; C: Confidential

Table 2.1b. Summary of national GHG emissions in 2000 (in Gg)

		HFCs					PFCs		SF6
		HFC-32	HFC-125	HFC 124	HFC 143	Others	CF4	Others	
1	**Energy**								
A	**Fuel Combustion Activity**								
1 A 1	Energy production (electricity, heat, oil & gas refining)								NE
1 A 2	Manufacturing Industries and Construction								
1 A 3	Transportation								
1 A 4 a	Commercial/Institutional								
1 A 4 b	Residential								
1 A 5	Non Specified								
B.	**Fugitive Emissions**								
1 B 1	Solid Fuels								
1 B 2	Oil and Natural Gas								
2	**Industrial Processes and Product Use**								
A.	**Mineral**								
2 A 1	Cement Production								
2 A 2	Lime Production								
2 A 3	Glass Production								
2 A 4	Other Process Uses of Carbonates								

		HFCs					PFCs		SF6
		HFC-32	HFC-125	HFC 124	HFC 143	Others	CF4	Others	
B.	**Chemical**								
2 B 1	Ammonia Production								
2 B 2	Nitric Acid Production								
2 B 4	Caprolactam, Glyoxal dan Glyoxylic Acid								
2 B 5	Carbide Production								
2 B 8	Petrochemical and Carbon Black Production								
	- Methanol								
	- Ethylene								
	- Ethylene Dichloride								
	- Carbon Black								
C.	**Metal**						NE	0.020	
2 C 1	Iron and Steel Production						NE	NE	
2 C 2	Ferroalloys Production						NE	NE	
2 C 3	Aluminium Production						IE	0.020	
2 C 5	Lead Production						NE	NE	
2 C 6	Zinc Production						NE	NE	
D.	**Others**								
2 D 1	Lubricant Use								
2 D 2	Paraffin Wax Use								
3	**Solvent and Other Product Use**								
4	**Agriculture**								
4 A 1	Enteric Fermentation								
4 A 2	Manure Management								
4 C 1 b	Biomass Burning CL								
4 C 1 c	Biomass Burning GL								
4 C 2	Liming								
4 C 3	Urea Fertilization								
4 C 4	Direct N_2O Soils								
4 C 5	Indirect N_2O Soils								
4 C 6 a	Direct N_2O from manure								
4 C 6 b	Indirect N_2O from manure								
4 C 7	Rice Cultivation								
5	**Land Use Change and Forestry**								
A	Changes in forest and other woody biomass stocks								
B	Forest and grassland conversion								
C	Abandonment of managed lands								
D	CO_2 emissions and removals from soils								
E	Others:								
	- Forest Burning								
	- Peat Fire*								
6	**Waste**								
6 A 2 a	Unmanaged Waste Disposal Sites								
6 A 2 b	Unmanaged Dumpsite								
6 B	Biological Treatment of Solid Waste								
6 C 2	Open Burning Waste								
6 D 1	Domestic WWT and Discharge								
6 D 2	Industrial WWT and Discharge								
7	Others (please specify)								
	Memo Items								
	International Bunkers								
	Aviation								
	Marine								
	CO_2 emissions from biomass								

Note: Shaded cells do not require entries. CL: Crops Land. GL: Grass Land. WWT: Wastewater Treatment; NO: Not Occurring; NE: Not Estimated; NA: Not Applicable; IE: Including Elsewhere; C: Confidential

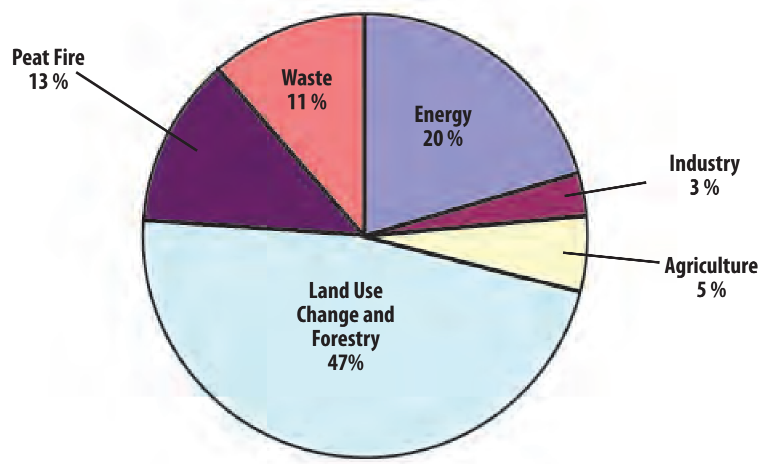


Figure 2.2 National emissions contributions by sector in 2000

Inter-annual variation of emissions from peat fires is also very high (Figure 2.3). High emissions normally occurred in El Niño years (1997, 2002, and 2006). The highest estimate was from Hooijer *et al* (2006), which estimated the emissions based on a Borneo hot-spot count and a carbon calculation method used by Page *et al*. (2002), who estimated emissions from peat fires in 1997 El Niño. This approach may give an overestimate, as hot-spot counts in peat lands are not fully proportional to CO_2 emissions, which are governed by additional factors such as the depth and area of burning. Therefore, this relationship may not be generally applicable for the whole of Indonesia and the extrapolation of emission estimates over Indonesia based on limited ground checks in Kalimantan may lead to overestimation.

Van der Werf *et al.* (2008) attempted to improve emission estimates from peat fires using several sources of satellite data with biogeochemical and atmospheric modelling to better understand and constrain peat fire emissions from Indonesia. This resulted in far lower estimates. The NGHGI adopted the study of the van der Werf *et al.* (2007). In 2000, their estimated emissions from peat fires were calculated at approximately 172,000 Gg CO_2e, while the ten-year average emissions from peat fire was about 466,000 Gg CO_2e from 1997-2007.

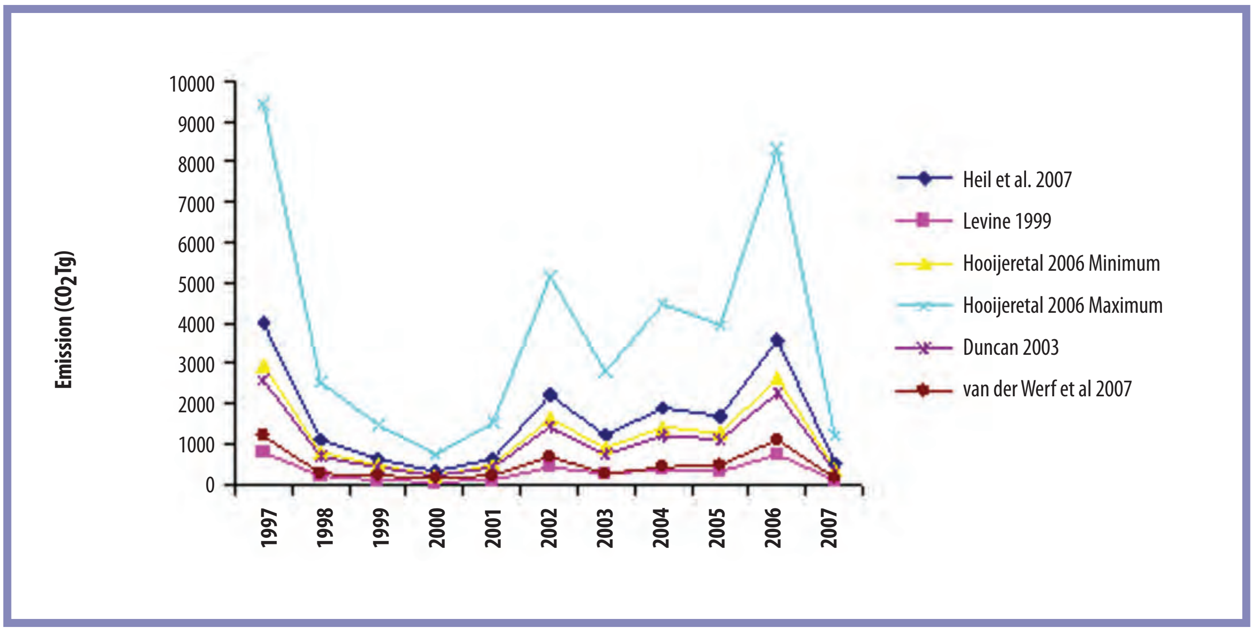


Figure 2.3 Estimate of emissions from peat fires from various studies. Note: Emissions estimates from years beyond the publication date of the reports were made by Aldrian (2008) and Wibowo and Boer (2009)

Emissions by Gas. Without LULUCF, the major source of CO_2 emissions is from fuel combustion, followed by industrial processes, agriculture and waste (Figure 2.4). Total emissions from these four sources was 556,500 Gg (Figure 2.4). With LULUCF and peat fire, the total CO_2 emissions increased to 1,112,879 Gg. As such, LULUCF and peat fire contributed to about 74% of the total CO_2 emissions (Figure 2.4).

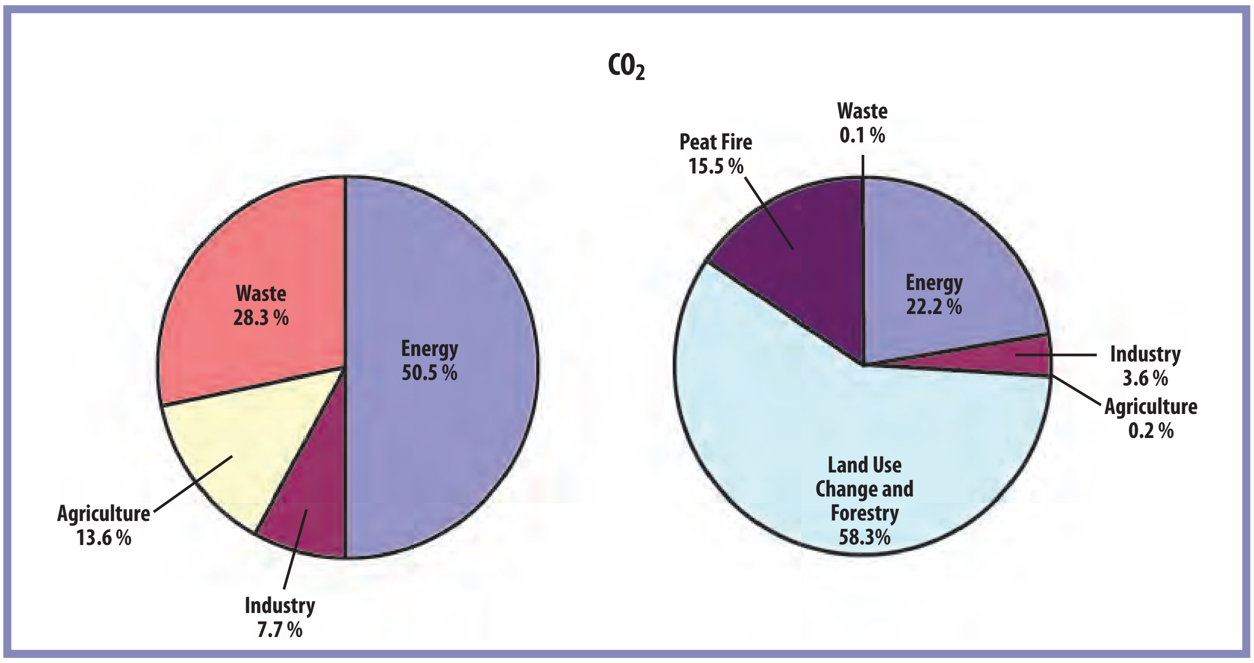


Figure 2.4 CO_2 emissions by sectors in 2000

The main source of methane emissions was the waste sector (65%), followed by the agriculture (22%) and energy (13%) sectors. The total methane emissions from all sectors was 236,388 Gg CO2e. For nitrous oxide, the main source of emissions was the agriculture sector (79%), followed by the waste (9%) and energy (11%) sectors (Figure 2.5). Total N2O emissions was 28,341 Gg CO2e.

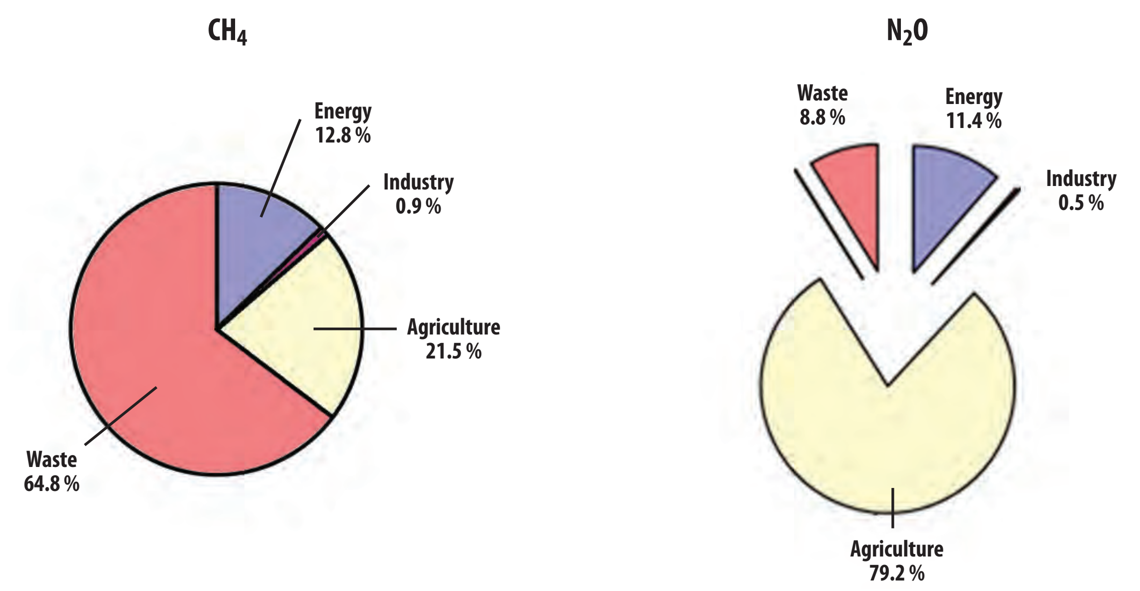


Figure 2.5 Methane and nitrous oxide emissions in 2000 by sector

2.5 Sectoral Emissions

2.5.1 Energy

In the 2006 IPCC Guidelines, emissions sources from energy systems are classified in three main categories, namely (i) fuel combustion emissions, (ii) fugitive emission generated from energy production systems (coal mining, oil and gas production, refinery, fuel transportation, etc), and (iii) emissions from transport, injection, and storage of CO_2 (related to carbon capture and storage [CCS]). Only the first two sources were included in the SNC. The source categories being analyzed in the SNC are presented in Figures 2.6 and 2.7.

The calculation of CO_2 emissions applied both sectoral and reference approaches. The two approaches often have different results because the reference approach is a top-down approach using a country's energy supply data and has no detailed information on how the individual fuels are used in each sector. In the case of Indonesia, CO_2 emissions from fuel consumption estimated using the reference approach were slightly higher than those using the sectoral approach in 2004. They differed between 4.3% and 4.7% (Figure 2.8). This can be at least partially attributed to the fact that the energy consumption figure used in the sectoral approach turns out to be less than the consumption figure used in the reference approach.

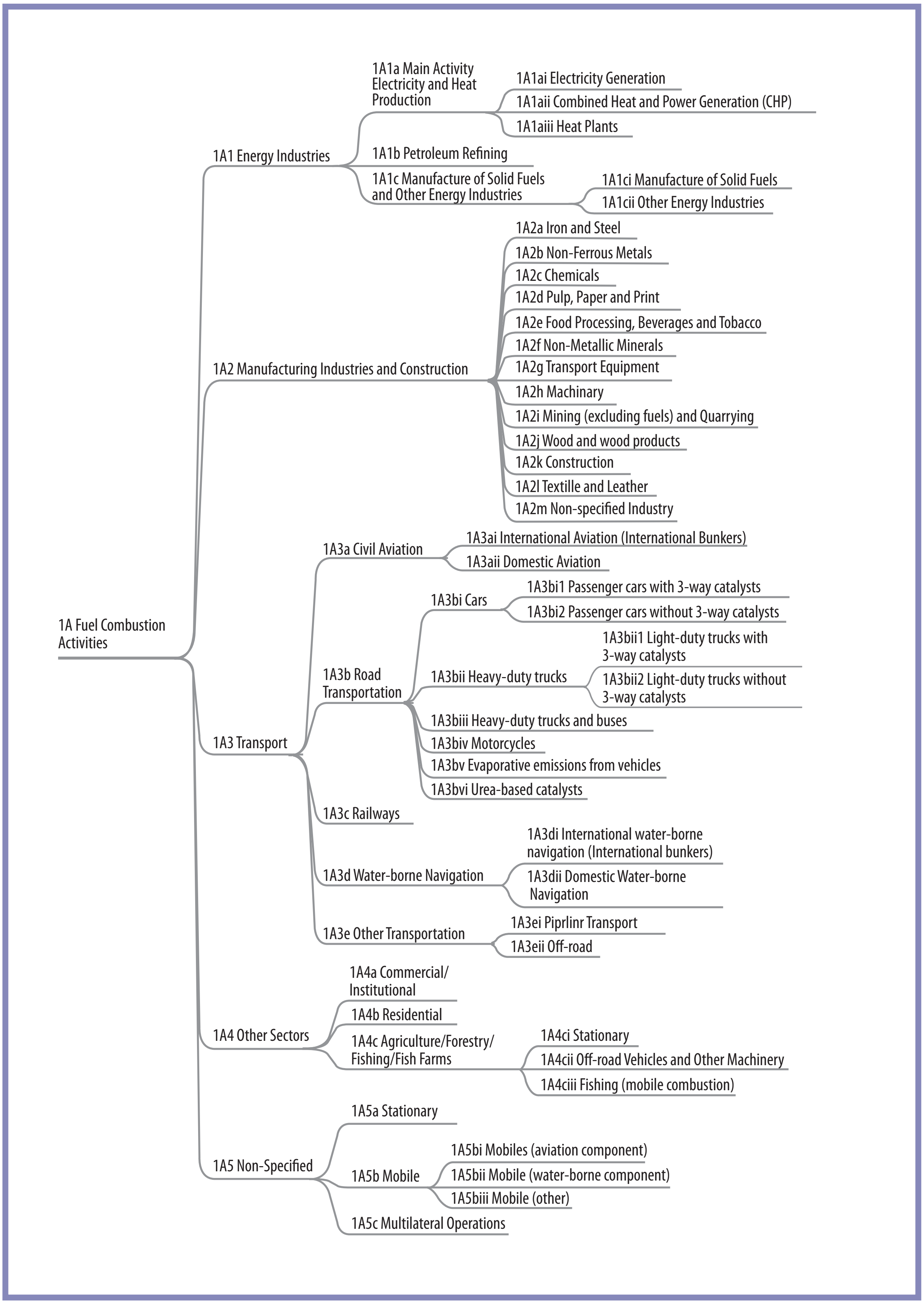


Figure 2.6 Source of GHG emissions from fuel combustion activities

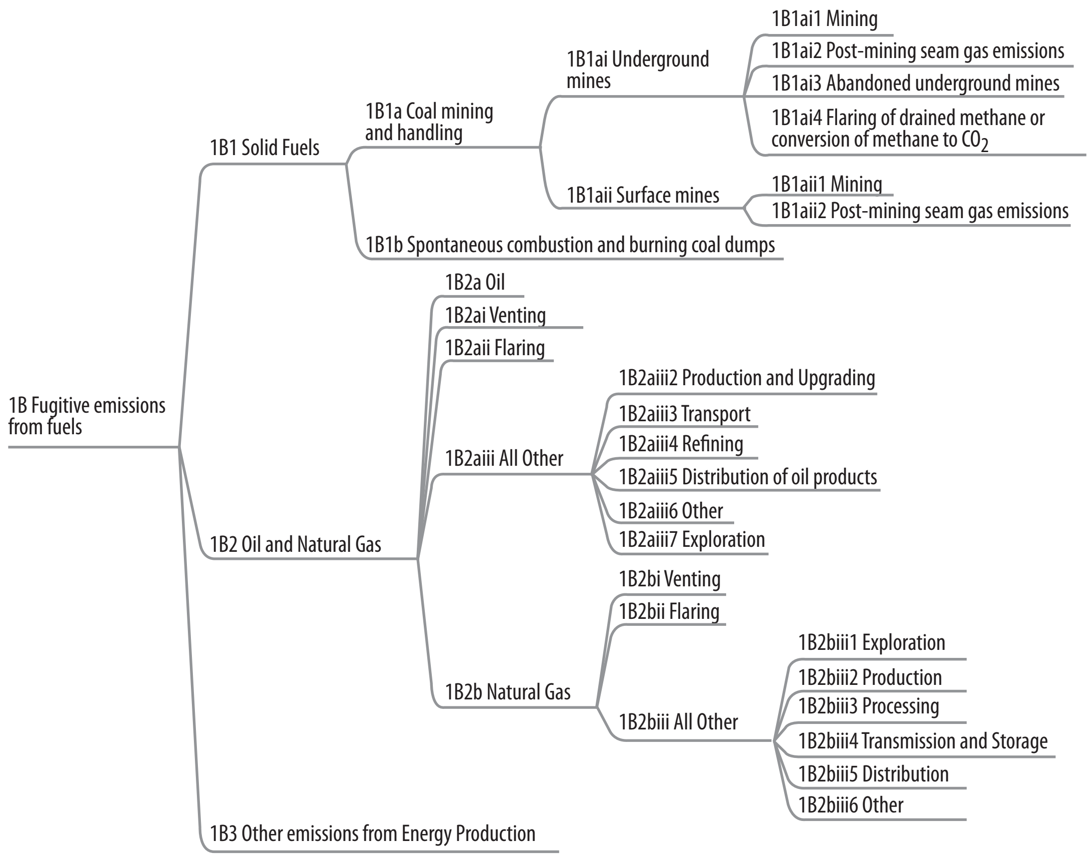


Figure 2.7 Source categories of fugitive emissions from fuels

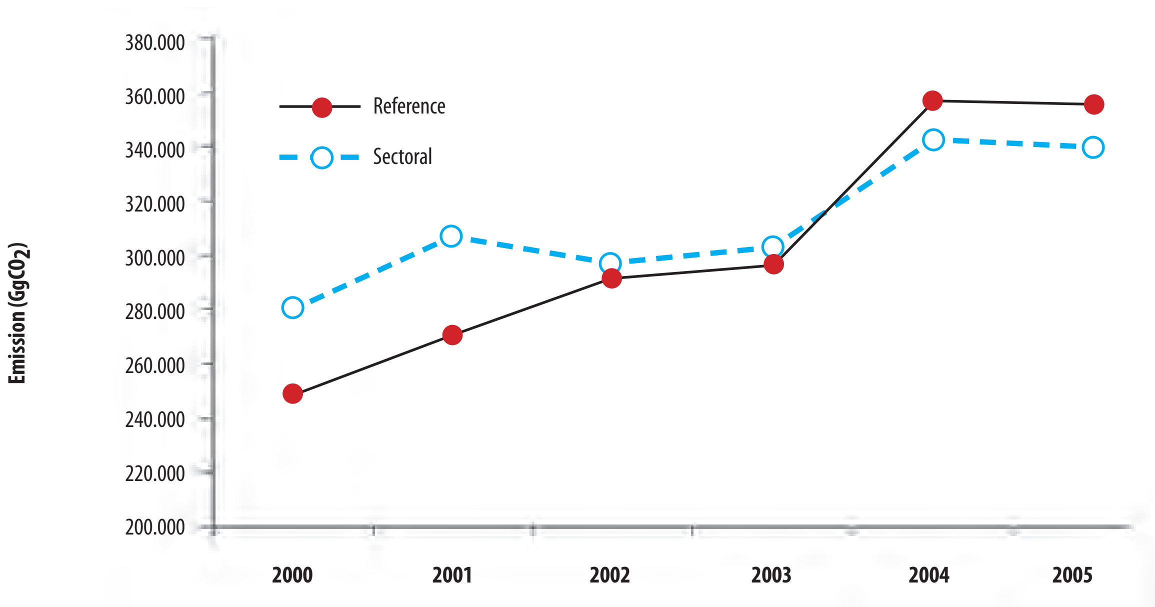


Figure 2.8 CO_2 emissions estimates from the energy sector using reference and sectoral approaches

Based on the sectoral approach, CO_2 was the main GHG emitted from the energy sector. It contributes approximately 89% of the total emissions from this category. Methane only contributed approximately 10% and N_2O contributed less than 1% (Table 2.2).

Table 2.2 Energy sector emissions from 2000 to 2005 by gas (Gg CO2e)

Type of Gases	2000	2001	2002	2003	2004	2005
CO_2	247,522	274,145	296,080	303,086	341,536	339,426
CH_4	30,175	29,263	28,366	27,315	26,662	26,711
N_2O	3,241	3,367	3,464	3,549	3,924	3,663
Total (GgCO_2e)	280,938	306,774	327,911	333,950	372,123	369,800

Emissions of CO_2 from the energy sector were mainly from fuel combustion, while the contribution of fugitive emissions was almost negligible (Table 2.3). Within the fuel combustion category, the main sources were electricity, petroleum and gas refining (35%), followed by transportation (23%), residential (9%) and manufacturing industries and construction (27%). In the period 2000-2005, CO_2 emissions from fuel combustion showed an increase from 240,877 Gg in 2000 to 333,438 Gg in 2005 (Figure 2.9), which represents a 38% increase, or 6.4% per year.

Table 2.3 CO_2 emissions from fossil consumption and fugitive emission from 2000-2005 (Gg CO_2e)

Activity	2000	2001	2002	2003	2004	2005
Energy (Gg CO_2)	247,522	274,145	296,080	303,086	341,536	339,426
Fossil fuel consumption (fuel combustion, (Gg CO_2)	240,877	267,782	289,615	296,688	335,546	333,438
Fugitive emissions from fuel (Gg CO_2)	6,645	6,363	6,466	6,398	5,991	5,988

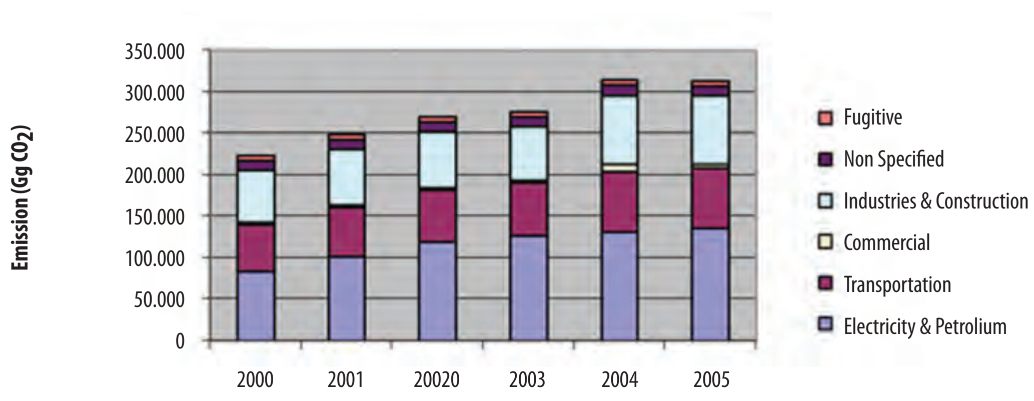


Figure 2.9 CO_2 emissions from the energy sector by source category

The annual GHG emissions growth rate from fuel consumption in Indonesia was higher than the Indonesian economic growth rate. This differs from other countries where gross domestic product (GDP) is higher than the emissions growth rate (Figure 2.10). Nevertheless, the CO2 intensity of the country has tended to sharply increase after 1998 and the Asian Financial Crisis (World Bank, 2008).

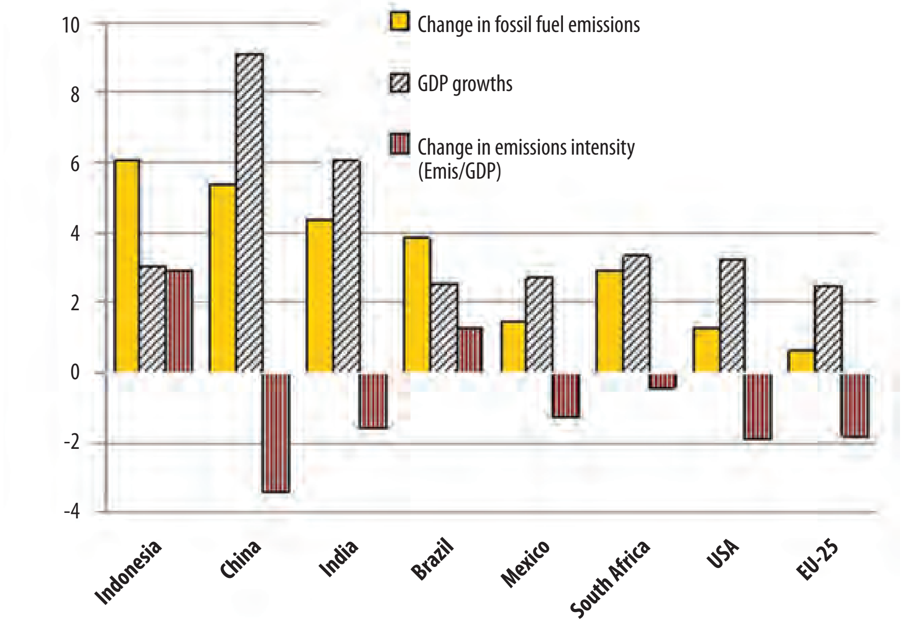


Figure 2.10 Annual Growth rate of CO2 emission and GDP of main emitter countries (World Bank)

2.5.2 Industry

GHG emissions from the industrial sector are comprised of CO_2, CH_4, N_2O, and PFC. PFC is emitted from the production of aluminum (Al) from a singlecompany. The technology used in the Al smelter is Centre-Worked Prebake (CWPB). Total GHG emissions in the form of CO_2e were 43,044 Gg in 2000 and increased to 48,733 Gg in 2005 (Table 2.4) – an increase of about 13.2% (2.2% per year). Indeed, there was a significant increase in emissions in 2001.

Table 2.4 GHG emissions from the industrial sector from 2000 to 2005 by gas (in Gg CO_2e)

GHG	2000	2001	2002	2003	2004	2005
CO_2	40,342	46,469	41,928	44,073	44,054	44,838
CH_4	2,423	3,022	1,452	3,450	3,787	3,572
N_20	133	174	190	233	0	178
PFC	145	145	145	145	145	145
Total (Gg CO_2e)	43,044	49,810	43,716	47,902	47,985	48,733

Major GHG emissions from production processes in the industrial sector are mainly from the production of mineral products (~67%), followed by chemical products (22%), metal products (10%) and others (1%) (Table 2.5). By sub-sector, the dominant sources of emissions are from the cement and ammonium industries (Figure 2.11). As evidenced in Figure 2.11, the two industries account for around 60-80% of the total CO_2 eq emissions in Indonesia.

Table 2.5 GHG emissions from the industrial sector from 2000 to 2005 by source category (in Gg CO_2e)

Source Category	2000	2001	2002	2003	2004	2005
Mineral	29153	34978	30310	30105	32425	32052
Chemical	10273	9514	10118	10447	9702	10982
Metal	3291	5001	3019	7029	5526	5347
Others	327	318	269	321	332	353
Total	43044	49810	43716	47902	47985	48733

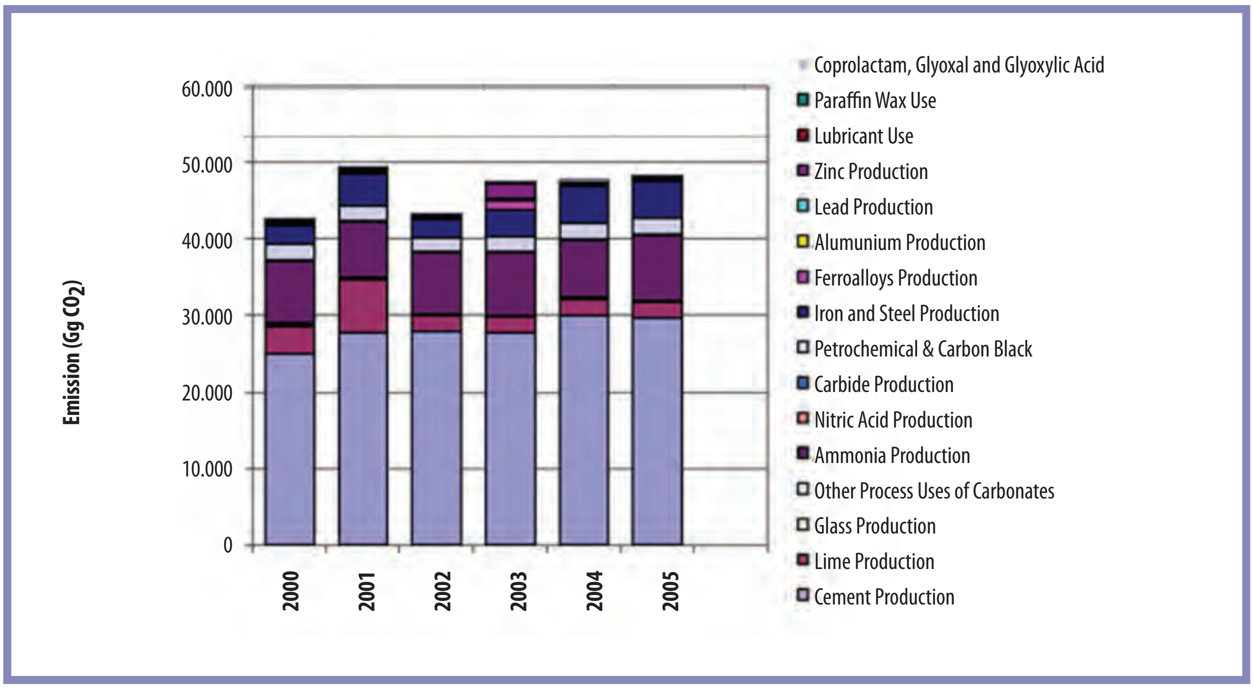


Figure 2.11 GHG emissions estimates from production process activities in the industrial secto

2.5.3 Agriculture

Unlike in other sectors, estimates of national emissions from the agriculture sector were based on emissions from districts and provinces. For rice cultivation, data were from the district level, while for livestock, data were from the provincial level. Because of this, variation in biophysical conditions between districts and provinces was taken into account in defining emissions factors.

From the analysis it was found that in 2000, total emissions of the three main GHGs (CO_2, CH_4 and N_2O) from this sector reached 75,420 Gg; by 2005, they had increased by 6.3% to 80,179 Gg CO_2e (Table 2.6). Methane contributed to approximately 65% of the total emissions, while N_2O contributed 31% and CO2contributed 4%.

Table 2.6 GHG emissions from the agriculture sector from 2000 to 2005 by gas (in Gg CO_2e)

Gas	2000	2001	2002	2003	2004	2005
CO_2	2,178	3,232	3,215	3,457	3,692	3,837
CH_4	50,800	50,677	50,833	52,547	49,342	50,670
N_2O	22,441	23,592	22,982	23,825	24,828	25,672
Total (in Gg CO_2e)	75,420	77,501	77,030	79,829	77,863	80,179

By source category, the major emissions were from rice cultivation, direct N_2O emissions and enteric fermentation from ruminants. These three sources accounted for approximately 83% of the total GHG emissions from this sector (Figure 2.12).

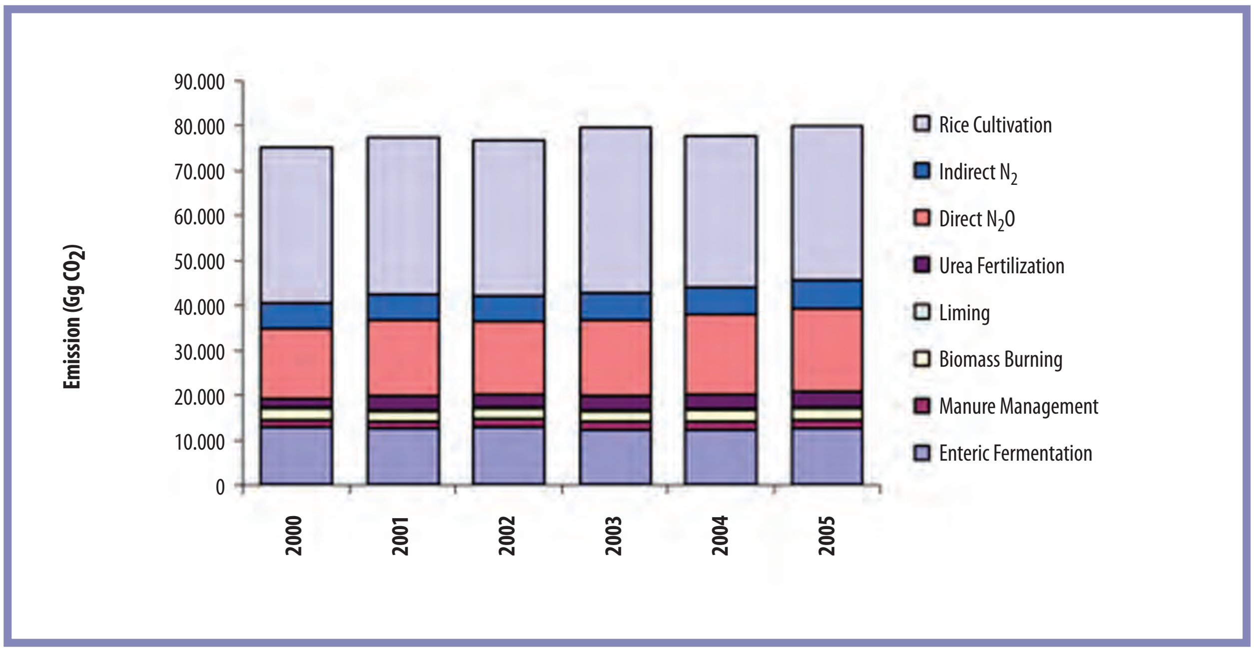


Figure 2.12 GHG emissions from the agriculture sector from 2000-2005 by source category

2.5.3.1 Livestock

Enteric Fermentation. Livestock populations in Indonesia are mostly concentrated in Java, Sumatra and Sulawesi. The highest number of ruminant animals is located in the East Java Province, followed by Nanggroe Aceh Darusalam (NAD; Table 2.7). Enteric fermentation is the most important source of methane emissions from livestock; these emissions are largely from beef cattle (62.8%), buffalo (16.0%) and goat herds (10.4%; Figure 2.13).

Table 2.7 Livestock population in Indonesia from 2000-2006

No.	Species Type	2000	2001	2002	2003	2004	2005	2006
1	Beef Cattle (AU)	8,121,691	8,069,525	8,183,187	7,546,157	7,547,990	7,561,691	7,799,932
2	Dairy Cattle (AU)	265,744	260,249	268,873	280,388	273,098	542,078	276,803
3	Buffalo (AU)	1,766,248	1,710,212	1,754,202	1,796,835	1,751,355	1,550,100	1,575,649
4	Sheep (head)	7,414,965	7,367,776	7,603,892	7,774,294	8,037,667	8,290,477	8,947,878
5	Goat (head)	12,613,108	12,198,587	12,292,318	12,465,046	12,592,730	13,203,098	13,567,972
6	Swine (head)	5,247,200	4,871,896	5,237,758	5,429,766	5,548,999	6,043,706	5,378,041
7	Horse (head)	412,919	404,162	396,697	388,599	376,378	365,478	373,981
8	Local Chicken (000 head)	261,132	268,786	276,023	278,068	278,966	281,431	292,122
9	Broiler (000 head)	534,811	624,690	849,644	855,669	785,547	820,501	808,510
10	Layer (000 head)	69,703	70,127	78,024	79,168	93,497	84,688	100,236
11	Duck (000 head)	29,674	32,591	46,624	34,547	33,255	33,102	33,195

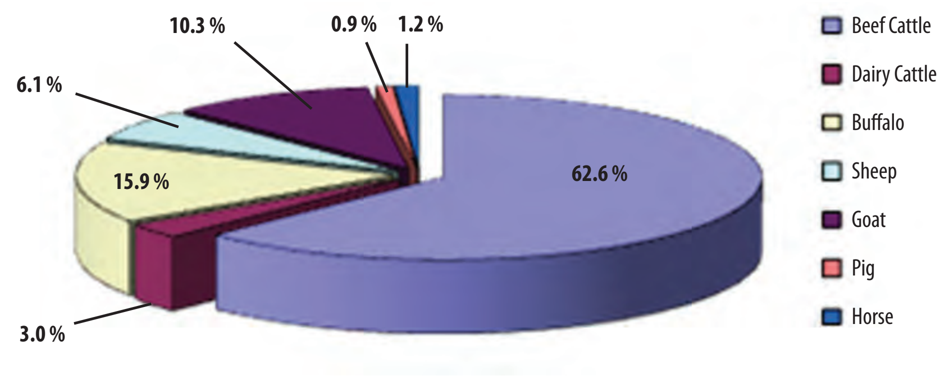


Figure 2.13 Distribution of methane emissions from enteric fermentation by species type

Methane Emissions from Manure Management. Methane emissions from manure management in 2000 were 79.69 Gg. Methane emissions from manure management were dominated by pig farms, which contributed 46.1%, followed by dairy cattle (10.3%) and beef cattle, which contributed the third largest emissions (10.2%) (Figure 2.14). East Java Province was the largest contributor, producing 9.72 Gg (12.2%), followed by Central Java at 8 Gg (12.2%) and North Sumatra at 7.7 Gg (1.9%). Methane emissions from manure management were small compared to enteric fermentation, comprising only13% of the total emissions from livestock (Figure 2.15).

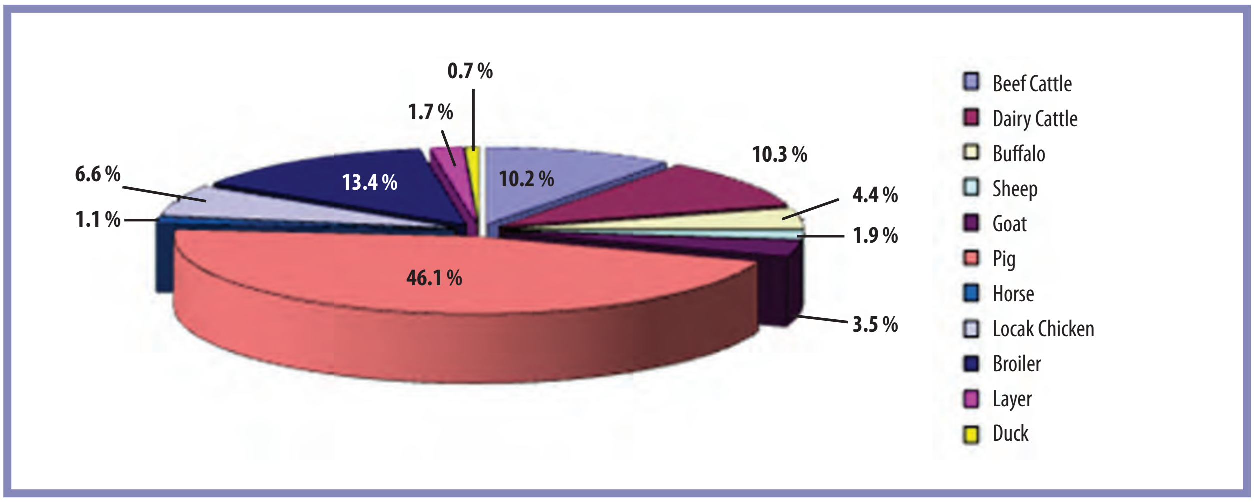


Figure 2.14 Distribution of methane emissions from manure management by species type

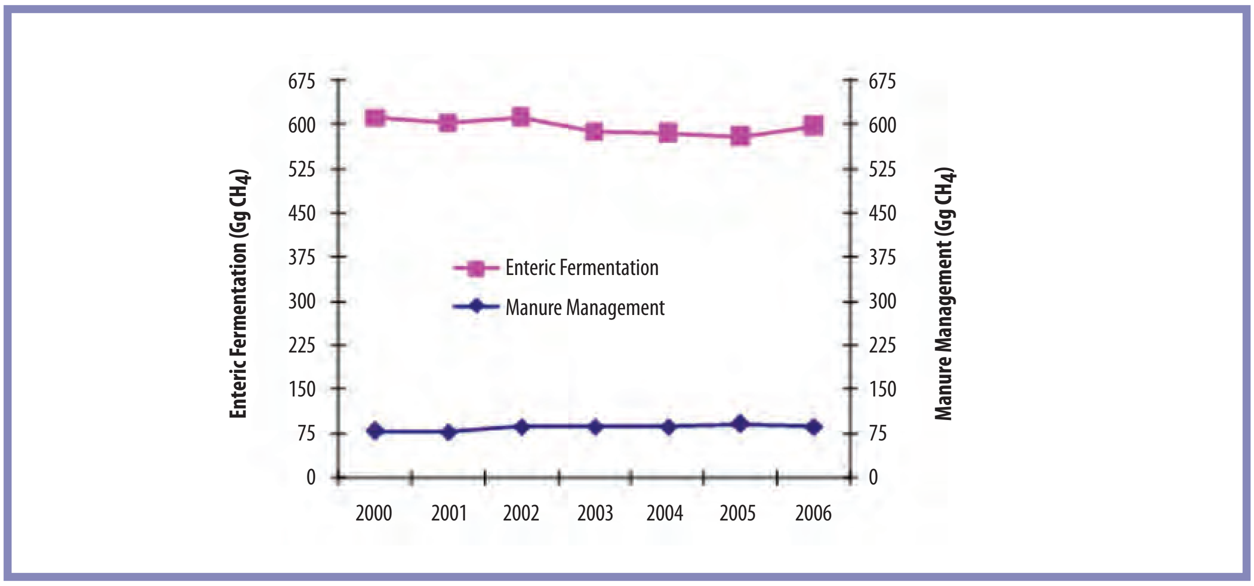


Figure 2.15 Methane emissions from livestock in Indonesia from 2000-2006

N_2O Emissions from Manure Management. Direct and indirect N_2O emissions from manure management are presented in Table 2.8. The annual direct N_2O emissions were 0.399 Gg, while the annual indirect N_2O emissions were 0.134 Gg. The total N_2O emissions from manure management was therefore 0.5130 Gg.

Table 2.8 Direct and indirect N_2O emissions from manure management

Manure Management System	Species Type	Number of Animal	Annual direct N_2O emissions (Gg/Year)	Annual indirect N_2O emissions (Gg/Year)
Pasture*	Beef Cattle**	2,436,507	-	-
Daily Spread	Dairy Cattle	265,744	0	0.000914
Dry Lot	Beef Cattle***	5,685,184	0.155217	0.023283
	Buffalo	1,766,248	0.042792	0.008558
	Sheep	7,414,965	0.055731	0.011146
	Goats	12,613,108	0.118935	0.023787
	Swine	2,623,600	0.008427	0.001896
	Horses	412,919	0.010372	0.002334
Poulty With Litter	Broiler	534,810,990	0.004555	0.022776
	Layer	69,702,890	0.000885	0.004426
Poultry Without Litter	Native Chicken	261,132,020	0.002211	0.012159
	Duck	29,674,120	0.000424	0.002331
Total			**0.399549**	**0.113610**

* The emissions from pasture is calculated in the section called "N20 emissions from managed soil"
** Beef cattle in pasture management system is 30% of population
*** Beef cattle in dry lot management system is 70% of population

2.5.3.2 Rice Cultivation

Activity data used to calculate the emissions from rice fields were based on data on the area of rice fields and planting intensity from BPS 2005. Scaling factors for different soil types and correction factors for rice farms based on different water regimes were compiled from various pieces of research in Indonesia. Total CH_4 emissions from Indonesian rice fields in 2000 and 2005 were 1,660 and 1,649 Gg, respectively (Figure 2.16). Methane emissions were calculated based on the proportion of rice field area in each of the years 2000, 2001, 2002, 2003, 2004 and 2005. Anincrease of 3.6% in 2003 from emissions in year 2000 can be attributed to the growth of rice harvested area, especially in the outer islands. Reduction of total CH_4 emissions by as much as 3.1% in 2004 was due to an El Niño event in the same year, which influenced almost all harvested rice areas in Indonesia.

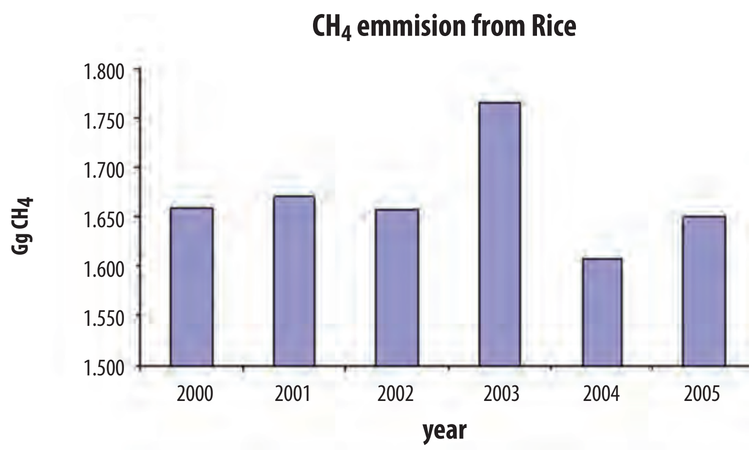


Figure 2.16 Methane emissions from rice cultivation from 2000-2005.

2.5.3.3 Agricultural Soils

Liming. Lime consumption data was not available during the data collection period for the SNC. Therefore, the CO_2 emissions from liming were determined from the recommended dose of lime for palm oil plantations in acid sulfate and peat soil (Note: liming on food crops is rarely applied by farmers). Using this method, the CO_2 emissions from liming from 2000 to 2005 are shown in Figure 2.17. Lime consumption in Indonesia increased, which is consistent withthe expansion of peatlands for palm oil plantation after the year 2000.

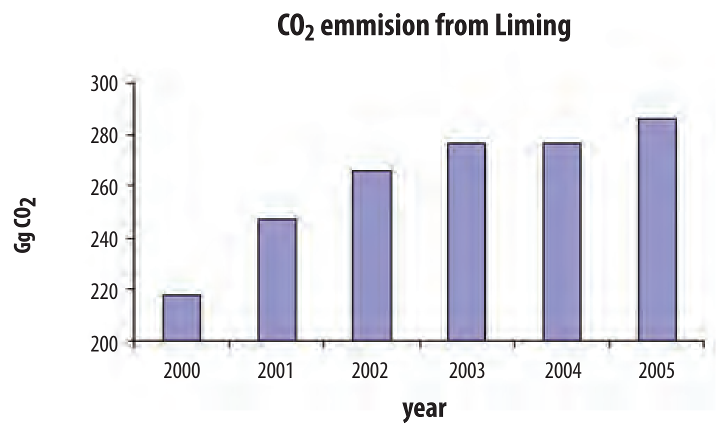


Figure 2.17 CO_2 emissions from liming in agriculture.

Urea Fertilization. Adding urea to soils during fertilization leads to a loss of CO_2 that was previously fixed in fertilizer during the industrial production process that manufactured it. Urea ($CO(NH_2)_2$) is converted into ammonium (NH_2^+), an hydroxyl ion (OH^-) and bicarbonate (HCO_2^-), in the presence of water and urease enzymes. Similar to the soil reaction following the addition of lime, the bicarbonate that is formed evolves into CO_2 and water.

Data on urea consumption for years 2000-2005 were derived from the Indonesia's Association of Fertilizer Producers (APPI). CO_2 emissions from urea application in the agricultural sector are shown in Figure 2.18. These emissions are currently increasing, as consumption of urea is increasing at an average rate of 4.5% per year since 2001.

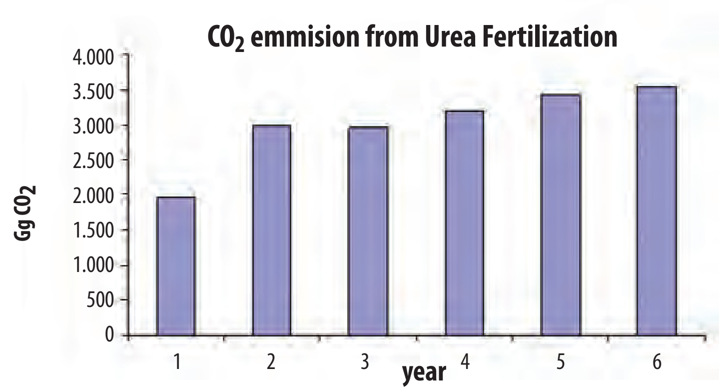


Figure 2.18 CO_2 emissions from urea fertilization from 2000-2005

N_2O Emissions from Managed Soils – Direct N_2O Emissions. Urea, ammonium sulphate (AS) and nitrogen, phosphorus and potassium (NPK) are the general types of inorganic nitrogen (N) fertilizers most commonly used in the agricultural sector of Indonesia. Urea and AS are the most common nitrogen-based inorganic fertilizers used in large plantations (APPI, 2008). This type of fertilizer is normally applied for fruits, vegetables and other perennial crops that have high economic value. The concentration of N in urea and AS is 46% and 21%, respectively (Petrokimia Gresik, 2008). However, data on NPK fertilizer consumption is not available. Instead, direct N_2O emissions on managed soil and flooded rice were calculated from the levels of application of N fertilizer and animal manure. The N fertilizer consumption data are only provided for urea and ammonium sulphate. N_2O emissions from flooded rice paddies were calculated based on harvested area of rice and from managed soil (i.e., maize, soybean and palm oil). Direct N_2O emissions from 2000-2005 from managed soil are shown in Figure 2.19. Fluctuation of N_2O direct emissions from managed soil, as shown in Figure 2.19, can be attributed to the consumption of urea and AS for agriculture in Indonesia. Urea is the main N source used in agriculture, mostly for food crops; however, AS is normally applied in plantation crops such as sugarcane. Some AS is used in rice fields to improve the number of tillers of rice plant.

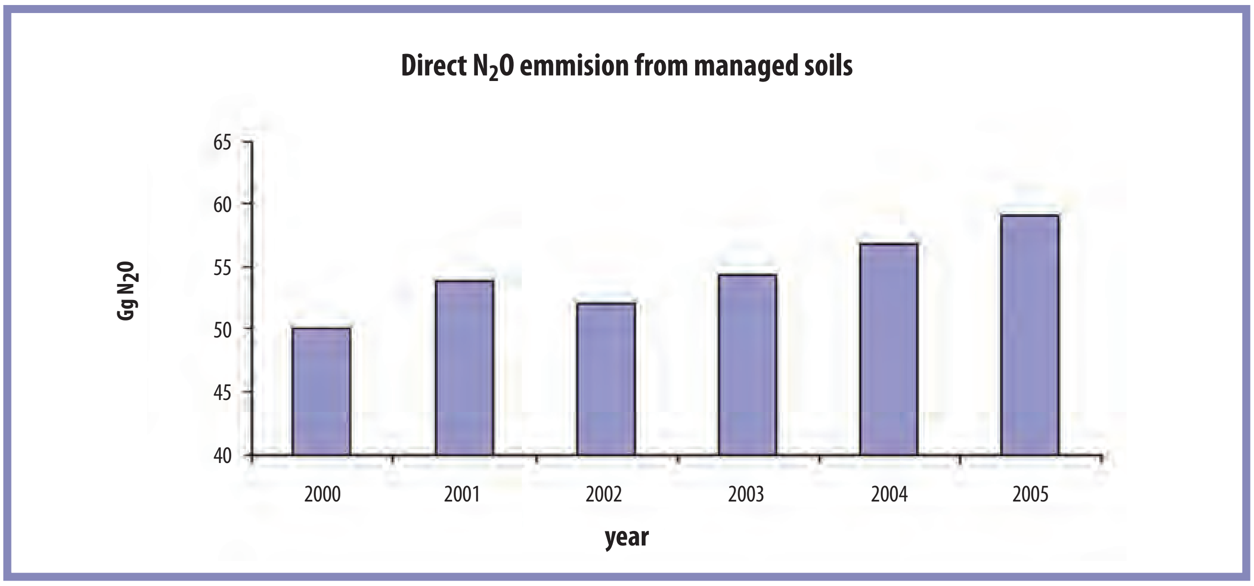


Figure 2.19 Direct N_2O emissions from N synthetic fertilizer and manure management applied to soils

N_2O Emissions from Managed Soils – Indirect N_2O Emissions. Indirect N_2O emissions from soil were also calculated based on the consumption of N fertilizer (urea, AS and animal manure) in agriculture. The indirect N_2O emissions from N fertilizer for perennial and estate crops were based on the N fertilizer consumption data from 2000 and the use of animal manure used in agricultural cropping. The resulting N_2O emissions calculated was approximately 18.34 Gg of N_2O/year (Figure 2.20).

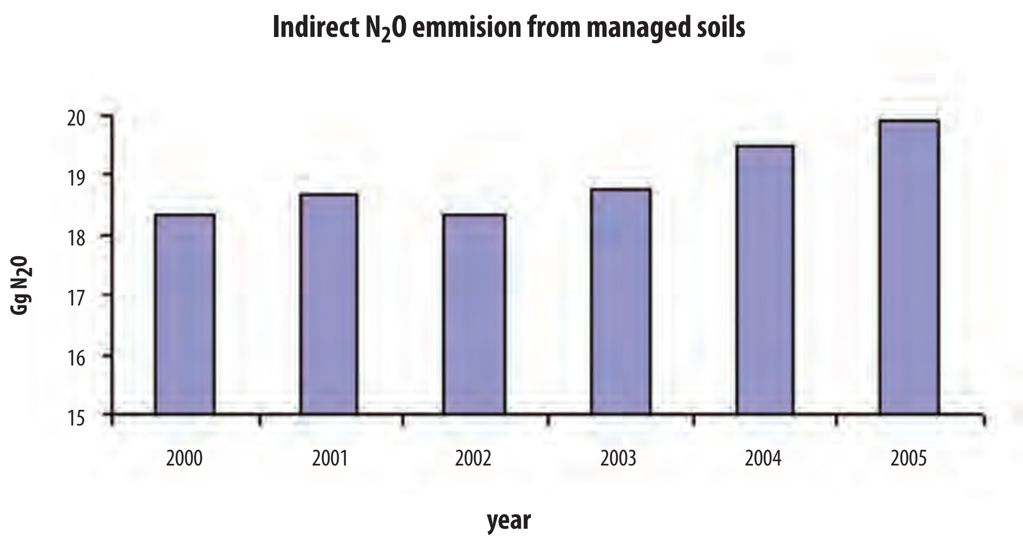


Figure 2.20 Indirect N_2O emissions from N synthetic fertilizer and animal manure applied to soils

2.5.3.4 Biomass Burning

Prescribed Savannah Burning (Grassland Burning). Emissions from grassland burning were calculated based on the 2000-2005 harvested area of upland rice data derived from BPS. Assumptions from expert judgment suggested that 80% of upland rice outside the island of Java was burned and that these areas conducted shifting cultivation; within Java, however, judgment suggested that burning of grassland is not common practice. The emissions of CH4, CO, N2O and NOx from cropland burning are shown in Table 2.9. Results showed that there were not significant differences in emissions from grassland burning between years.

Table 2.9 Distribution of GHG emissions from grassland burning from 2000-2005 (Gg CO_2e)

GHG's emission	2000	2001	2002	2003	2004	2005
CO_2	-	-	-	-	-	-
CH_4	24.05	21.29	21.31	21.86	22.70	22.51
N_2O	2.20	1.94	1.95	2.00	2.07	2.06
CO	679.78	601.61	602.23	617.90	641.44	636.17
NO_x	40.79	36.10	36.13	37.07	38.49	38.37
CO_2e	1,187.05	1,048.49	1,052.01	1,079.06	1,118.40	1,111.31

Field Burning of Agriculture Residue (Cropland burning). Emissions from cropland burning were calculated based on the 2000-2005 rice production data derived from BPS. Assumptions from expert judgment mentioned that the proportion (harvest index) for yield and biomass is

1:1, and the fraction of biomass that is burned differs between regions. The emissions of CH_4, CO, N_2O and NO_x from cropland burning are shown in Table 2.10.

Table 2.10 Distribution of GHG emissions from cropland burning from 2000-2005 (Gg)

GHG's emission	2000	2001	2002	2003	2004	2005
CO_2	-	-	-	-	-	-
CH_4	47.39	43.86	45.45	45.79	47.63	47.44
N_20	1.23	1.14	1.18	1.19	1.23	1.23
CO	1,614.90	1,494.66	1,548.68	1,560.22	1,623.03	1,616.36
NO_x	43.88	40.62	42.08	42.40	44.10	43.92
CO_2e	1,376.17	1,274.46	1,319.74	1,330.47	1,381.53	1,377.48

2.5.4 Land Use Change and Forestry (LUCF)

Application of the 2006 IPCC GL for LUCF requires consistent land categories to estimate emissions and removal of GHGs for all land categories, relevant carbon pools, and non-CO2 gases (based on key source/sink category analysis). This has implications for the activity data required and emissions factors for all land categories, carbon pools and related non-CO2 gases. Since land categories in the 2006 IPCC GL are different from current forest classes applied by Directorate Forestry of Forestry Planning (Ministry of Forestry), the forest categories by Ministry of Forestry were grouped following the 2006 IPCC GL in developing the GHG inventory for this sector, as shown in Table 2.11.

Table 2.11 Adjustment of Indonesia's land category by Ministry of Forestry into 2006 IPCC GL categories

No.	Forest Category (MoF, 2008)	2006 IPCC Land Category
1.	Primary Dry land Forest	Forest Land
2.	Primary Swamp Forest	Forest Land
3.	Primary Mangrove Forest	Forest Land
4.	Secondary Dry land Forest	Forest Land
5.	Secondary Swamp Forest	Forest Land
6.	Secondary Mangrove Forest	Forest Land
7.	Plantation Forest	Forest Land
	Other land use (APL)	
8.	Shrubs	Grassland
9.	Swamp shrubs	Wetland
10.	Open lands	Other Land
11.	Swamp	Wetland
12.	Agriculture	Cropland

No.	Forest Category (MoF, 2008)	2006 IPCC Land Category
13.	Mix agriculture shrubs	Cropland
14.	Transmigration	Cropland
15.	Settlement	Settlement
16.	Grassland	Grassland
17.	Rice field	Cropland
18.	Estate crops	Cropland
19.	Dyke	Other Land
20.	Airport	Other Land
21.	Water Body	Wetland
22.	Clouds	Undefined

At present, the Directorate of Forestry Planning (Ministry of Forestry) is still in the process of producing time series data of land use and forest cover activity data using satellite imagery. Meanwhile, the GHG inventory presented here used Tier 1 data that compiles information from official reports, such as the Forestry Statistical Report (Ministry of Forestry), Indonesia Statistics (BPS), and other references. For emissions removal/factors, most data (i.e., biomass growth and carbon stock for some land uses) is taken from country-specific studies (Tier 2). Emissions from peat fires were not estimated by the National GHG Inventory Team, thus emissions estimates from peat were taken directly from available studies.

In reporting the GHG inventory, the source categories follow the 1996 IPCC GL as suggested in the Guidelines for National Communications of non-Annex I Parties of the UNFCCC, adopted in decision 17/CP.8. Therefore, the results of emissions estimates were mapped back to the 1996 IPCC GL format.

In 2000, total net emissions from three main GHGs (CO_2, CH_4 and N_2O) from this sector reached 821,254 Gg (Table 2.12). In the following years, the rate of emissions fluctuated considerably. In 2001, it decreased by approximately 8%; in 2002, it increased sharply by approximately 139%. This fluctuation was primarily due to high inter-annual variation of deforestation rates and peat fires. Within each year, rates of carbon removal were quite stable.

Table 2.12 GHG emissions and removal from LUCF (in Gg CO_2e)

Gas	2000	2001	2002	2003	2004
CO_2-sequestration	-411,593	-402,027	-384,427	-435,037	-431,128
CO_2	1,232,766	1,156,433	2,349,902	1,026,507	1,488,520
CH_4	56	140	14	13	22
$N_2 0$	24	0	6	6	9
Net emissions	**821,254**	**754,546**	**1,965,495**	**591,489**	**1,057,423**

By source category, forest and grassland conversion are the main sources of emissions, followed by peat fires and peat oxidation (i.e., emissions from organic soils) (Figure 2.21). However, from 2000-2004, the contribution of forest and grassland conversion to the total emissions from this sector varied between 48% and 65%, peat fire between 15% and 32% and peat oxidation between 10% and 25%. The 2008 World Bank study, however, gave different estimates. It reported that the average emissions from LUCF were approximately 2,398,000 Gg, in which 53% were from peat fire, 20% were from peat drainage (peat oxidation), 22% were from deforestation and 5% were from palm oil and timber plantation establishment.

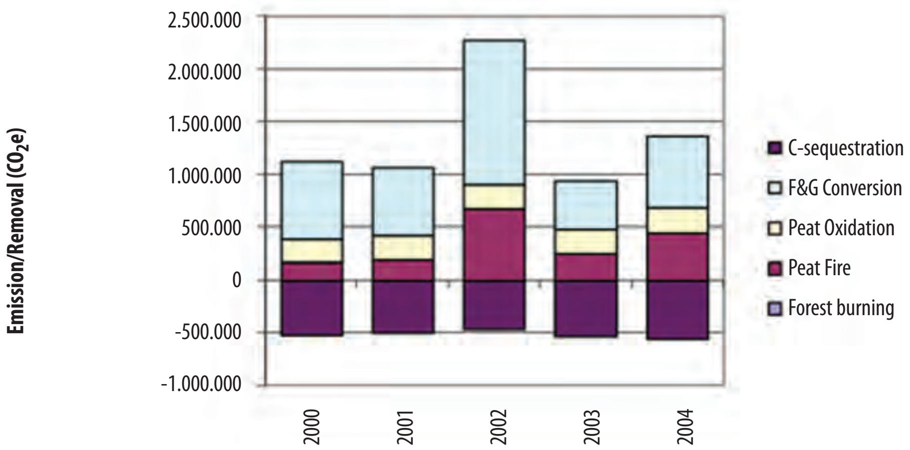


Figure 2.21 GHG emissions from LUCF sector from 2000-2004 by source category

The contribution of peat fires to the total national emissions could actually be higher since the estimate of emissions from available studies varies considerably (Table 2.13). The lowest estimates were from Indonesian Forest Climate Alliance (IFCA) study (MoF, 2008) while the highest was from Hooijer *et al,* (2006). Hooijer et al (2006) estimated the emissions based on a Borneo hot-spot count and a carbon calculation method used by Page *et al*. (2002), who estimated emissions from peat fires during the 1997 El Niño. This approach may lead to an overestimate as hot-spot counts in peat lands are not fully proportional to CO_2 emissions, which are governed by additional factors such as the depth and area of burning. Therefore, this relationship may not also be generally applicable for the whole of Indonesia, and so the extrapolation of emission estimates over Indonesia based on limited ground checks in Kalimantan may lead to overestimation. Van der Werf *et al*. (2008) attempted to improve emissions estimates from peat fires using several sources of satellite data with biogeochemical and atmospheric modelling to better understand and constrain peat fire emissions in Indonesia. This resulted in far lower estimates. The NGHGI adopted the study of the van der Werf *et al.* (2007). In 2000, the authors' estimated emissions from peat fires were calculated at about 172,000 Gg CO_2e, while the ten-year average emissions from peat fires (1997-2007) were approximately 466,000 Gg CO_2e .

[1] The use of average emissions figures from 1997-2007 could reduce the inter-annual variation

Table 2.13 Emissions from peat fires according to relevant studies (in Gg)

Year	Heil *et al* (2007)	Levine (1999)	Hooijer *et al*, 2002 Lowest	Hooijer *et al*, 2002 Highest	Duncan, *et al.* (2007)	van der Werf *et al.* (2007)	IFCA (MoF, 2008)	Average
1997	4,026,000	898,000	2,970,000	9,423,000	2,567,000	1,202,000	*16,600*	3,015,000
1998	1,082,000	242,000	799,000	2,534,000	689,000	271,000	*3,700*	803,000
1999	623,000	139,000	458,000	1,459,000	396,000	190,000	*2,600*	467,000
2000	304,000	*66,000*	224,000	711,000	194,000	172,000	*2,400*	239,000
2001	645,000	*143,000*	477,000	1,511,000	411,000	194,000	*2,700*	483,000
2002	2,204,000	*491,000*	1,624,000	5,155,000	1,404,000	678,000	*9,400*	1,652,000
2003	1,188,000	*264,000*	*876,000*	*2,783,000*	*759,000*	246,000	*3,400*	874,000
2004	1,907,000	*425,000*	*1,408,000*	*4,462,000*	*1,217,000*	440,000	*6,100*	1,409,000
2005	1,694,000	*378,000*	*1,250,000*	*3,960,000*	*1,078,000*	451,000	*6,200*	1,260,000
2006	3,560,000	*796,000*	*2,625,000*	*8,334,000*	*2,270,000*	1,111,000	*15,300*	2,673,000
2007	524,000	*117,000*	*385,000*	*1,225,000*	*334,000*	*175,000*	*2,400*	395,000
Average	1,614,000	360,000	1,191,000	3,778,000	1,029,000	466,000	6,400	1,206,000

Note: Figures in italic represent predictions using emissions pattern according to Heil et al. (2007), as defined in Aldrian (2008). IFCA (2007) only provided estimates of cumulative emissions from 2000-2005 equal to 30 million tons of CO2. For annual emissions, the proportion of emissions followed the proportion used in van der Warf et al (2007)

A different selection of emissions estimates from peat fire would significantly change the emission figures of Indonesia. Table 2.14 shows the change in national emissions figures due to changes in the selection of the peat emissions figures and the relative position of Indonesia as an emitter country.

Table 2.14 Impact of selecting different emissions estimates from peat fire on national figures and the relative position of Indonesia as an emitter country

No.	Option	Emissions from peatfires (Gg CO_2)	Total (+1,244,000 Gg CO_2)	Global emitter rangk
1	Peat fires in 2000– highest (Page *et al*, 2002)	711,000	1,955,000	5th
2	Peat fires in 2000 – lowest (IFCA, 2007)	2,400	1,246,000	7th
3	Peat fires in 2000 – latest (van der Warf *et al.*,2008)	172,000	1,416,000	7th
4	Average –highest (Hooijer *et al.*, 2002)	*3,778,000*	5,022,000	2nd
5	Average –lowest (IFCA, 2007)	*6,400*	1,250,000	7th
6	Average of all studies, all years	*1,206,000*	2,450,000	3rd
7	The latest average (van der Warf *et al.*,2008)	*466,000*	*1,710,000*	*6th*

2.5.5 Waste

According to the 2006 IPCC GL, sources of emissionsfrom the waste sector are found in four main categories: solid waste, biological treatment of solid waste, incineration and open burning of waste and wastewater treatment and discharge, as shown in Figure 2.22.

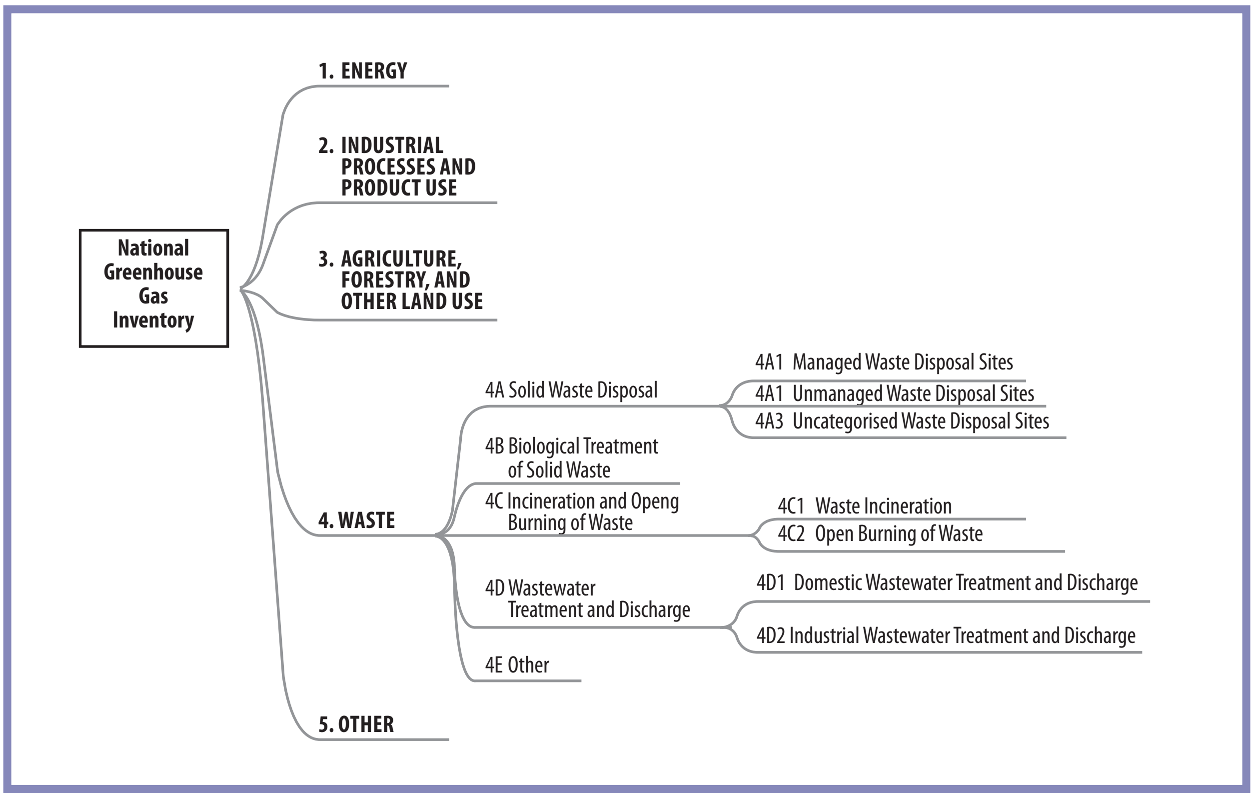


Figure 2.22 Categories of GHG emissions sources within thewaste sector

– Concerning solid waste disposal: In urban areas, almost 60% of waste is taken to solid waste disposal site (SWDS), while in rural areas or small cities, this figure is only 30% (Indonesian Statistical Data on Environment; BPS, 2007). The major components of solid waste brought to SWDS areorganic compounds as the other types of waste (plastics, metal, etc.) are generally recycled for re-utilization. The dominant organic compound in solid waste will affect the degradable organic content (DOC) value and the corresponding correction of the CH4 emissions factor in inventories. The SWDSs in most big cities in Indonesia are considered to beunmanaged SWDS because they are simply open dumping systems; within the context of GHG emissions, they are catagorized as unmanageddeep (>5 m) waste.

  Currently, incinerators for municipal solid waste are generally not used in Indonesia. Although several statistical data indicate that inceration is already used for eliminating municipal solid waste, in reality, the so-called 'incinerator' is actually an 'open burning' system. Therefore, the calculation of CO_2 emissions from municipal solid waste is based on open burning.

- Concerning domestic wastewater: In general, the discharge pathways of domestic wastewater in urban areas in Indonesia are decentralized using individual septic tanks. In rural areas, there is almost no wastewater treatment.

- Concerning industrial wastewater: In general,industrial wastewater is treated by the industry prior to discharge to the environment. The calculation of GHG emissions level varies according to the type of industry and the corresponding treatment technology.

From this analysis, it was found that the 2000 total net emissions from the three main GHGs (CO_2, CH_4 and N_2O) of the waste sector reached 157,328 Gg (Table 2.15). Methane contributed to approximately 97% of the total emissions. The rate of emission in the period from 2000-2005 was relatively stable. By source category, the major sources are from wastewater treatment and discharge (Figure 2.23).

Table 2.15 GHG emissions and removal from waste (in Gg CO_2e)

Gas	2000	2001	2002	2003	2004	2005
CO_2	1,662	2,266	2,302	2,338	2,366	2,377
CH_4	153,164	155,853	157,516	158,670	160,361	161,346
N_2O	2,501	2,699	2,982	3,066	3,072	3,108
Total	157,328	*160,818*	162,800	164,074	165,799	166,831

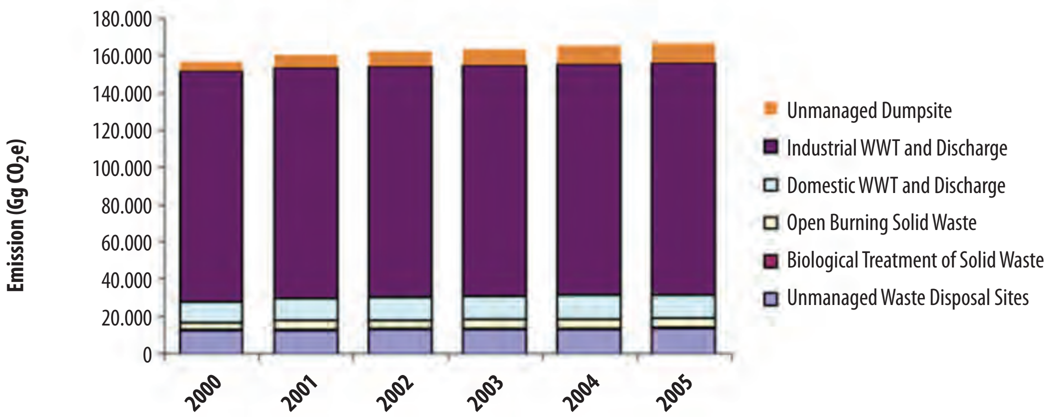


Figure 2.23 GHG emissions from the waste sector from 2000-2005 by source category

2.6 Emissions Trends

Of the five sectors considered here, there are only three sectors where the rates of emissions have increased. These sectors are energy, agriculture and industry, while emissions from the waste sector were relatively constant and those from the LUCF sector fluctuated considerably between years (Figure 2.24). The net emissions from the LUCF sector were the lowest in 2003. In 2003, the rate of reforestation was relatively high while rate of deforestation was low.

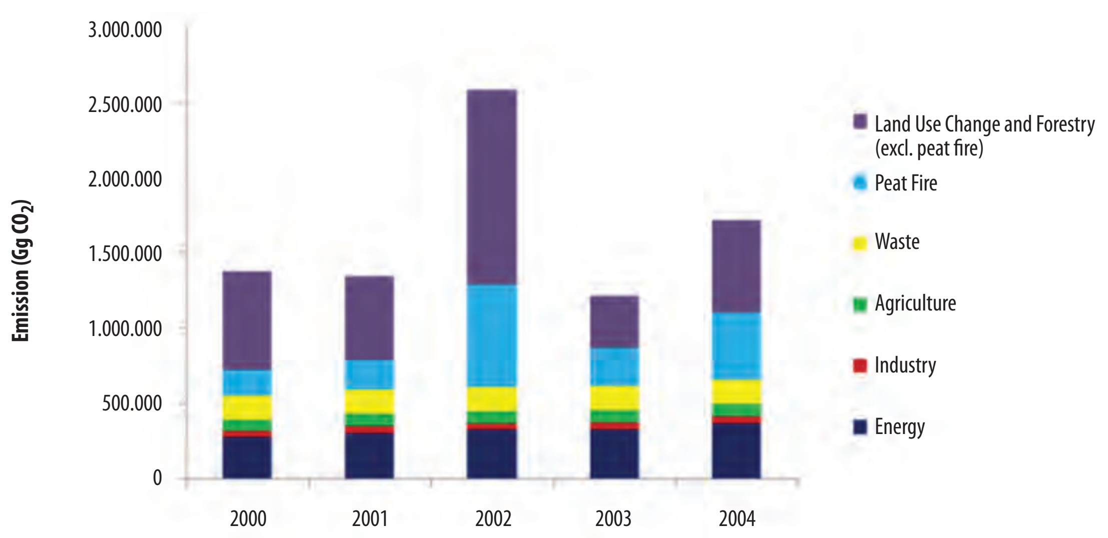


Figure 2.24 Emissions trends by sector

2.7 Key Category Analysis

The key category analysis (Tier 1) without and with LUCF indicated that there are 20 and 5 key categories respectively. Without LUCF, the first three main categories that contributed to more than 50% of the total emissions were (i) energy production (electricity, heat, oil & gas refining), (ii) industrial wastewater treatment and discharge and (iii) manufacturing industries and construction (Table 2.16). With LUCF, the first three main categories are all from the LUCF sector. These include (i) forest and grassland conversion, (ii) peat fire and (iii) CO_2 emissions and removals from soils. This analysis suggests that improvement of activity data and emission factors for these key categories were very important to improve the Indonesian National GHG Inventory. It appears that activity data on land use and forest change area and the forested area are the most important. Local emission factors for these source categories need to be developed.

Table 2.16 Key Category Analysis

Sector	Source Categories to be Assessed in Key Source Category Analysis	Gases	Cumulative Contribution (%)
	Without L U C F	2,266	2,302
Energy	Energy production (electricity, heat, oil & gas refining)	CO_2	19.8
Waste	Industrial Wastewater Treatment and Discharge	CH_4	38.5
Energy	Manufacturing Industries and Construction	CH_4	50.9
Energy	Transportation	CO_2	61.8

Sector	Source Categories to be Assessed in Key Source Category Analysis	Gases	Cumulative Contribution (%)
Agriculture	Rice Cultivation	CO_2	66.9
Industrial Process	Cement Production	CH_4	71.4
Energy	Residential	CO_2	75.6
Agriculture	Direct N20 Soils	CO_2	78.2
Energy	Oil and Natural Gas	N_2O	80.6
Waste	Unmanaged Waste Disposal Sites	CH_4	82.6
Energy	Non Specified	CH_4	84.6
Agriculture	Enteric Fermentation	CO_2	86.5
Waste	Domestic Wastewater Treatment and Discharge	CH_4	88.0
Waste	Unmanaged Dumpsite	CH_4	89.5
Energy	Residential	CH_4	91.0
Energy	Commercial/Institutional	CH_4	92.3
Industrial Process	Ammonia Production	CH_4	93.5
Agriculture	Indirect N20 Soils	CO_2	94.4
Energy	Oil and Natural Gas	CO_2	95.3
With L U C F			
LUCF	Forest and grassland conversion	CO_2	39.6
LUCF	Peat Fire	CO_2	65.2
LUCF	CO2 emissions and removals from soils	CO_2	79.3
Energy	Energy production (electricity, heat, oil & gas refining)	CO_2	86.9
Waste	Industrial Wastewater Treatment and Discharge	CH_4	94.1
Energy	Manufacturing Industries and Construction	CO_2	98.9

2.8 Uncertainty Analysis

An uncertainty analysis was conducted (Tier 1) following the Good Practice Guidance (GPG) IPCC 2000. The levels of uncertainty for activity data and emission factors were assessed based on expert judgment and consultation with the Centre for Data and Information in the related sectors (Table 2.17). Overall uncertainty of the Indonesian National GHG inventory for 2000 and 2004 without LUCF was approximately 16.3% and 13.9%, respectively, while the trend uncertainty was 16.9%. With the inclusion of LUCF, the level of uncertainty of the National GHG Inventory increased between 15% and 20% (Table 2.18).

Improving activity data and emissions factors for the LUCF sector (the first three key categories) could increase the certainty of the inventory (cf. Table 2.17 and 2.18). This improvement is possible with the use of satellite data. Emissions/removal factors can also be improved with the use of data from National Forest Inventory (NFI). At the time of this inventory, the NFI data is still being processed and not available for use. With the availability of this data, the overall certainty of the Indonesian National GHG Inventory can be improved significantly.

Table 2.17 Estimates of uncertainty level for activity data and emissions factors

No.	Source/Sink Categories	Current Uncertainty		Improved	
		AD	EF/RF	AD	EF/RF
1	Energy and transportation	10	5	Same	Same
2	Industry1	10	10	Same	Same
3	Agriculture	15	30	Same	Same
4a	Change in forest and other woody biomass	25	50	15	25
4b	Forest and grassland conversion	30	75	15	25
4c	Abandonment of managed land	25	50	Same	Same
4d	Soil emissions	50	75	Same	Same
4e	Peat burning (van der Werf et al. 2008)	25	50	15	25
5	Waste	50	50	Same	Same

Note: [1]The level of uncertainty for sub-categories of industrial process varied from 5 to 15 while for other sectors were assumed to be the same. AD = activity data; EF/RF = emissions factor/removal factor

Table 2.18 Level of current uncertainty of Indonesian National GHG Inventory for 2000 and 2004 and trend and potential reduced uncertainty with the incorporation of necessary improvement for the first three key source categories

Sectors	Year	Uncertainty	
		Current	Improved
Without LUCF	2000	16.3	NA
	2004	13.9	NA
	Trend	16.9	NA
With LUCF	2000	47.0	23.0
	2004	38.5	20.0
	Trend	32.2	20.3

2.9 Quality Assurance/Quality Control (QA/QC)

At present there is no system in place for QA/QC for the GHG emissions. However, the Bureau of Statistics and several other agencies that are responsible for collecting data from local governments and private companies have set up procedures for data quality checking. In the future, sectors that are responsible for developing the National GHG Inventory will develop QA/QC systems. The Ministry of Environment has proposed SIGN (Sistem Inventarisasi Gas Rumah Kaca Nasional) or a National GHG Inventory System to BAPPENAS (National Agency for Planning and Development) to be one of Indonesia's priority climate change programmes. The overall objective of SIGN is to strengthen the capacity of sectors and local governments in order to improve the quality of the GHG inventory for the development of a sustainable inventory management system. There are three priority focus areas under SIGN:

1. Improvement of methodologies, activity data and emission factors;

2. Strengthening institutional arrangements, their functions, and operations of archiving, updating and managing of greenhouse gas inventories; and

3. Increasing awareness of local governments on the importance of the National GHG Inventory for developing mitigation strategies. Increasing the capacity of designated personnel of the GHG Inventory within each sector for developing and managing the GHG inventory.

2.10 Plans for Improvement

Indonesia plans to improve emissions estimates through the improvement of activity data and emissions/removal factors. Priority will be given to LUCF and the agriculture sector.

For the LUCF sector, priority will be given to the improvement of emissions/removal factors from peat and forestland. The initiatives being undertaken include:

a. Development of emissions factors from peat lands under different uses. Research is being conducted in Central Kalimantan by National Research Consortium for Climate Variability and Climate Change for Agriculture Sector under the coordination of the Ministry of Agriculture. The research is planned to expand to other provinces with support from Global Environment Facility (GEF) using funding allocated for the 3rd National Communication.

b. Development of emissions/removal factors from forestlands and emissions factors from fire (both in mineral soils and peat land), including the improvement of activity data using satellite, aerial photography and radar by the Ministry of Forestry and partner agencies. The program is operating under INCAS (Indonesian National Carbon Accounting System), a collaboration between Government of Indonesia and Government of Australia.

c. Implementation of a pilot study to improve GHG emissions estimates from peat lands in the West Kalimantan and Riau Provinces under the coordination of the State Ministry of Environment.

d. Estimates of CO_2 emissions from peat land using best available activity data (AD) from the sectors and emissions factor/removal factor (EF/RF) from recent studies under the coordination of BAPPENAS in collaboration with Centre for Climate Risk and Opportunity Management-Bogor Agriculture University (CCROM-IPB), Directorate General of Planology – Ministry of Forestry (BAPLAN-MoF), and Center for Agiculture Land Resources and

Development – Ministry of Agriculture (BBSLDA-MoA). This study attempts to use recent findings from the studies conducted by the Ministry of Agriculture under the National Research Consortium for Climate Variability and Climate Change and Indonesia's National Carbon Accounting System (INCAS) project.

For the agriculture sector, the National Research Consortium is undertaking the improvement of emissions and removal factors for climate variability and climate change. The activities include:

a. Development of a correction factor for GHG emission from livestock. According to Suryahadi et al. (2001), feeds influenced the rate of energy converted to methane. Because feed management systems of livestock production in Indonesia varies, the correction of emissions factors must be based on the feed condition, particularly organic matter (OM) and energy consumption level. The emissions factors from the livestock sub-sector can also be corrected by considering animal population structure.

b. Development of a correction factor for methane emissions from various rice cultivars and emissions factor for fertilizer application (N_2O emission factors) and emissions from application of different nitrogen resources and organic fertilizer.

c. Improvement of activity data on the fraction of biomass burning, to complete information on the proportion of crop residue burned, for animal consumption and industry. Data used to calculate emissions from biomass burning are only based on the proportion of rice being harvested in Indonesian rice fields. It was assumed that the proportion is 1:1; however, this proportion may only represent irrigated rice and not rain-fed and upland rice.

d. Improvement of activity data on biomass residues from non-rice crops, such as dry land and industrial crops (i.e., corn, peanuts, soybean, palm oil, cacao, sugar cane, etc). Those crops have a high carbon/nitrogen ratio as compared to rice and probably have higher CO_2emissionscompared to rice.

e. Development of sequestration capacity of different agriculture system particularly perennial crops that increase sharply in last decades.

f. Establishment of national database on carbon balance (GHG emission and sequestration) on agriculture through regular monitoring.

CHAPTER III

General Description of Steps Taken or Envisaged to Implement The Convention

3.1 Introduction

Following Indonesia's ratification of the United Nations Framework Convention on Climate Change (UNFCCC) in 2004 and the Kyoto Protocol in 1997, the Goverment of Indonesia (GOI) stated its strong commitment to support global efforts to combat climate change. As stated in its Article 3.4, the Convention urges member parties of the UNFCCC to incorporate climate change into national development planning. Article 4.1 of UNFCCC also underlines the needs of all countries to develop their specific national development priorities and objectives in accordance to principles of common but differentiated responsibilities. Then, in the 13th Conference of Parties (COP13) in2007, the UNFCCC delivered the Bali Action Plan, addressing long-term cooperative action on climate change and reiterating references to the need for developing countries to integrate adaptation actions into sectoral and national planning, specific projects and programmes. Moreover, the developing countries also need to enhance mitigation actions in the context of the global sustainable development agenda.

In an effort to maintain the spirit of COP13, the GOI made a number of significant efforts to effectively implement the UNFCCC post-conference. These include (i) the development of a number of policy documents outlining the GOI's efforts in integrating climate change mitigation and adaptation activities into the National Medium-Term Development Plan (Rencana Pembangunan Jangka Menengah Nasional, or RPJMN) and (ii) the preparation and the issuance of regulations that assist sectors and local governments in the implementation of climate change programs.

3.2 Process of Integrating Climate Change into the National Development Plan

The GOI has started several initiatives to integrate mitigation and adaptation climate change principles into national development planning agenda. The climate issue has been mentioned clearly in the Long-Term National Development Planning 2005-2035 (RPJMP 2005-2035). The plan highlights the various disasters caused by extreme climatic events in Indonesia, including the recent floods and droughts that have brought about heavy losses to the national economy. The National Mid-Term Development Plan (RPJMN 2004-2009) has also set the stage for integrating climate change into national development planning. Climate change is described in Chapter 19 on Agriculture, Fishery and Forestry Revitalization, Chapter 28 on Improvement of People's Access to Quality Health Services, Chapter 32 on Improvement of Natural Resources and Environmental Management, and Chapter 33 on Acceleration of Infrastructure Development. The main focus of the Plan is to integrate climate change into cross-sectoral development priorities. In the Annual Government Work Plan (Rencana Kerja Pemerintah, RKP) 2008 (RKP 2008), climate change was addressed through the Disaster Risk Reduction Program (which includes meteorological disasters), one of the RKP's eight priority programs. As a consequence, the budget allocation for the Meteorological Early Warning System (MEWS) program in BMKG (Meteorology, Climatology, and Geophysical Agency) has been augmented to improve the national early warning system for climate variability in Indonesia.

In order to fine-tune the current and the subsequent development plan, particularly in formulating the mid-term national plan (RPJMN 2010-2014) and the annual work plan (RKP 2009 and RKP 2010) to be more responsive and address sectoral and cross sectoral issues sensitive to climate change impacts, BAPPENAS, through collaboration with various government institutions, developed "The National Development Planning: Response to Climate Change" documentas also known as "The Yellow Book."The Yellow Book shall also serve as reference for the international community to support climate change-related policies, programs and activities prioritized by the GOI. To develop the Yellow Book, BAPPENAS used recent studies related to climate change in Indonesia such as the Technological Needs Assessment, National Communications, Climate Change National Action Plan, etc. Linkages between climate change related documents, development planning and the budgeting process are shown in Figure 3.1.

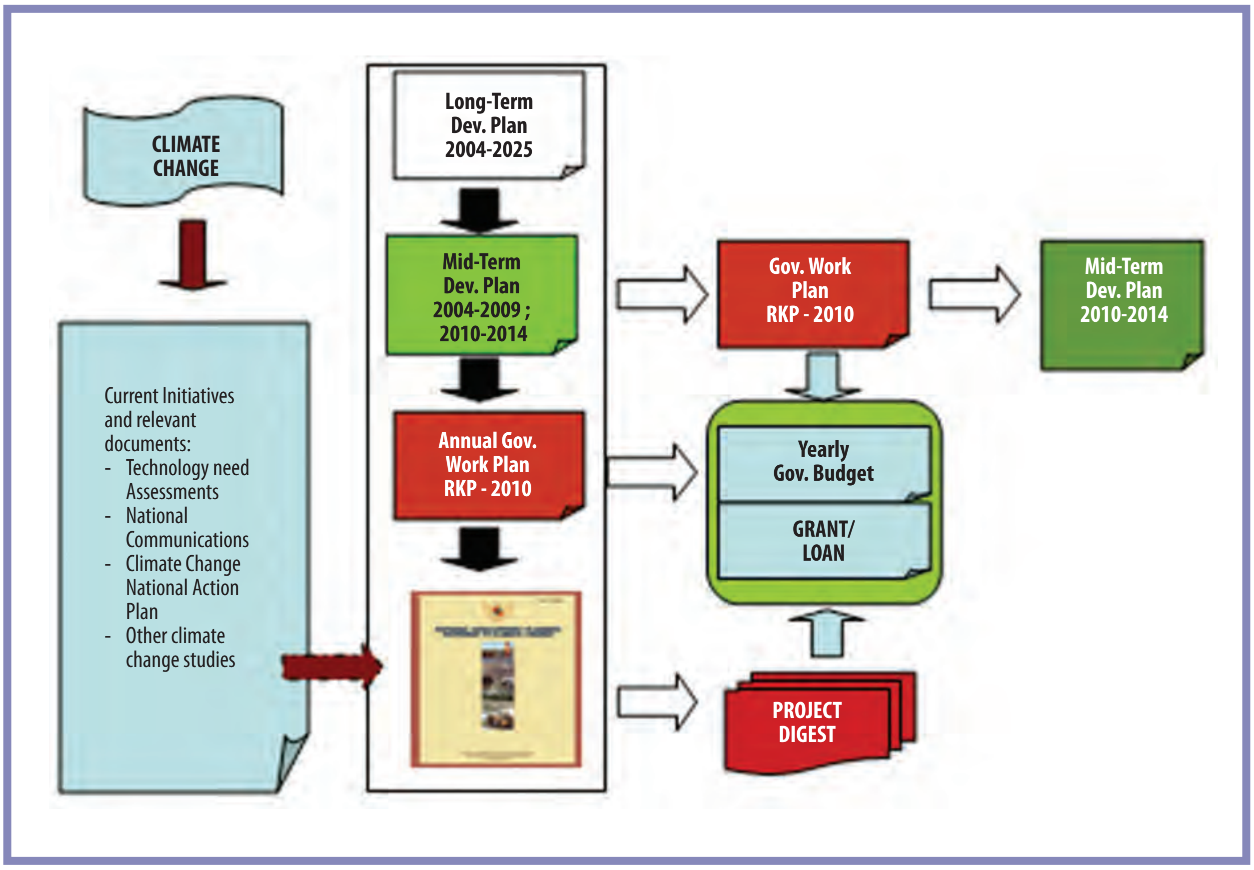


Figure 3.1 Linkages between climate change-related documents, development planning and the budgeting process

To provide guidance for synergizing programs and actions on climate change adaptations and mitigations within sub-sectors, each sector under the coordination of BAPPENAS developed a sectoral roadmap. The roadmap provides sectoral policy direction, strategies and programs to address climate change, and sectoral long-term commitment to emissions reductions and adaptation measures as well as ongoing, innovative and future climate mitigation and adaptation programs. Thus, the roadmap provides detailed policy guidance for climate change planning, programming and actions. Figure 3.2 presents the process of developing the climate change sectoral roadmap.

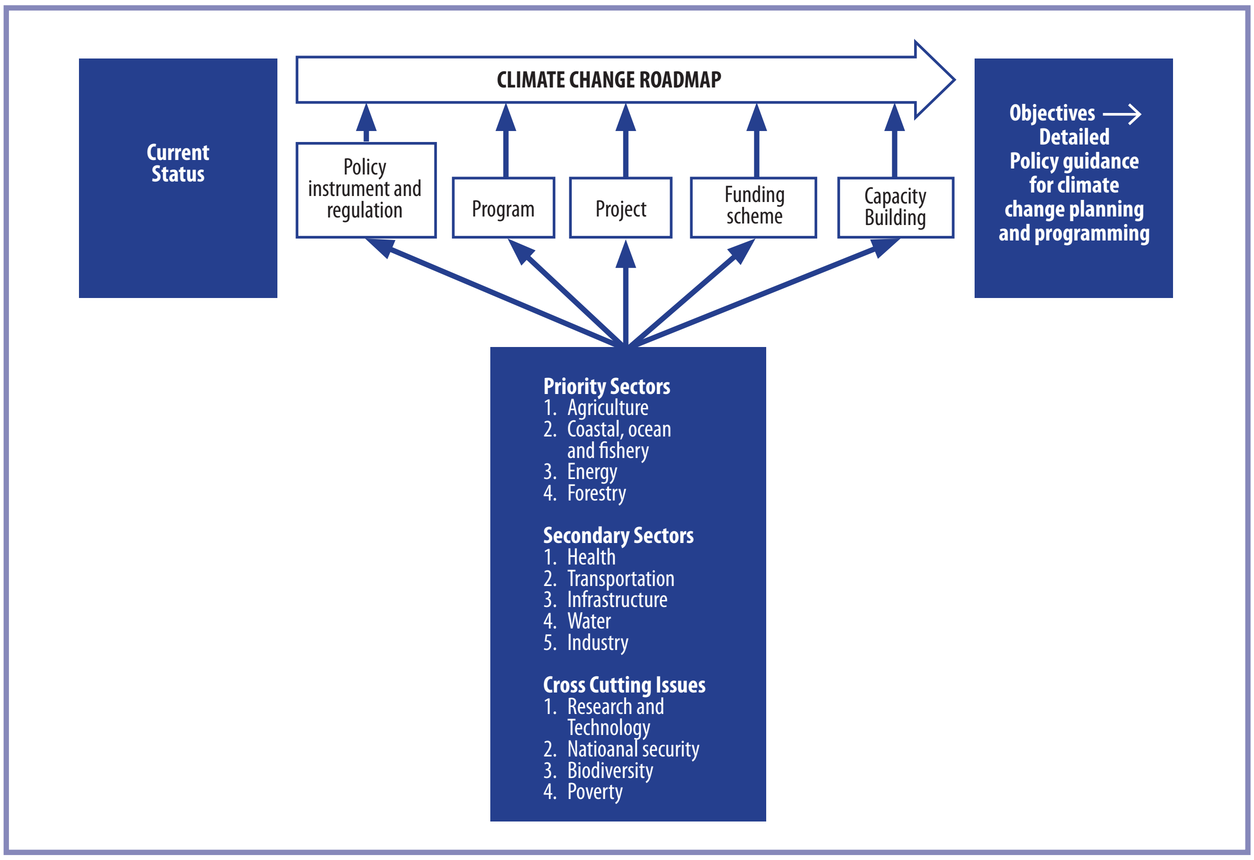


Figure 3.2 Development of the climate change roadmap

Following commitment of the GOI to actively participate in reducing its emissions through National Appropriate Mitigation Action (NAMA), in 2009, the President of the Republic of Indonesia at the G-20 meeting inPittsburgh and at COP15 in Copenhagen committed to an ambitious, world-leading target of 26% reduction in carbon emissions from Business As Usual (BAU) by 2020. Further emissions reductions of 41% are expected with international support. With this commitment, Indonesia will follow a low carbon development path. As such, BAPPENAS is coordinating the sectors to develop the National Action Plan for Reducing Greenhouse Gas Emissions (RAN-GRK). The GOI lists three principles in the RAN-GRK, stating that the mitigation actions (i) should not hinder economic growth, and should prioritize people's welfare, especially in with regard to energy resilience and food security, (ii) support protection of poor and vulnerable communities, including environment conservation in the framework of sustainable development and (iii) consist of core activities to reduce emissions and supporting activities to strengthen the policy framework. Figure 3.3 shows the interconnection between policies, guidelines, roadmaps and investment funds towards low carbon development. One new source of funds to support the implementation of climate change programs in Indonesia is the Indonesian Climate Change Trust Fund (ICCTF), described briefly in the following section.

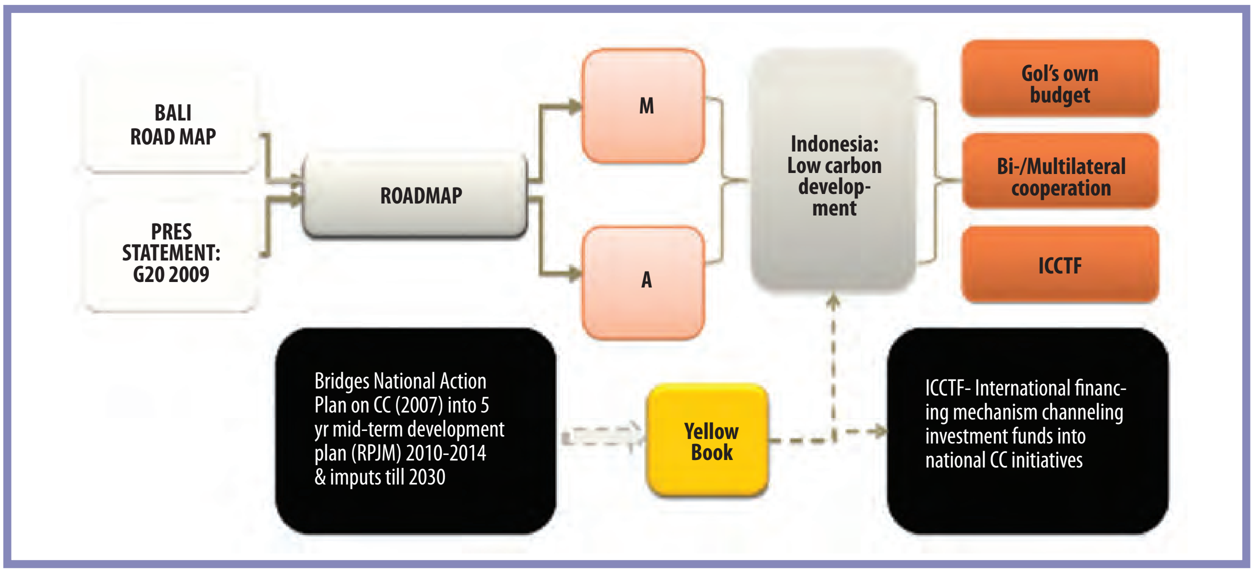


Figure 3.3 Process of mainstreaming climate change into national agenda: Policies, guidelines, roadmaps & investment funds (BAPPENAS, 2009b). Note: M is mitigation and A is adaptation.

3.3 Financial Institutions

Climate change issues are one priority focus of the national development planning policy. This focus includes the improvement of environmental management and control, capacity building and institutional set-up for the climate change-related stakeholders and the capacity building related to the disaster management. Current government funding for climate change-related programs is insufficient. Indonesia recognizes that climate change can only be properly addressed by allocating specific funding to the issue. In the past, government activities targeting climate change were embedded into regular development programs; with no specific national budget allocated to climate change, funding was instead main streamed into existing programs.

To avoid economic down turn and overcome funding difficulties that may a rise when addressing the impacts of climate change, international support plays a key role in enabling Indonesia to effectively develop and implement climate change programs. In this regard, the GOI prioritizes grant utilization to finance climate change programming. Grants to fund climate change activities can originate directly from bilateral or multilateral donors (under Official Development Assistance [ODA] rules and procedures) or via a trust fund (under related trust fund rules and procedures). However, loan resources can be utilized when grant funding is insufficient and the utilization of loans will be the last alternative (BAPPENAS, 2009b). Nevertheless, the GOI recognizes the importance of establishing a management system to link international financial resources with national investment strategies since this external cooperation and financing needs to be properly prepared for and managed. The GOI has set up the previously mentioned financing management system for supporting and accelerating the implementation of climate change programs called the Indonesian Climate Change Trust Fund (ICCTF).

The ICCTF aims to be a showcase of alternative financing for climate change mitigation and adaptation programs (BAPPENAS, 2009b). At this stage, the ICCTF has five specific objectives:(i) to facilitate and accelerate investment in renewable energy and efficiency and simultaneously reduce GHG emissions from the energy sector, (ii) to reduce emissions from deforestation and forest degradation and stabilizing carbon stock through sustainable forest and peat land management, (iii) to reduce vulnerability in coastal zones, agriculture and water sectors, (iv) to bridge the financial gaps necessary to address climate change mitigation and adaptation and (v) to increase the effectiveness and impact of external finance for climate change programs.

At the initial phase, the ICCTF will be created as an "Innovative Fund," which involves grant funding from development partners that will help overcome barriers for early program deployment. At the later stages, the ICCTF may advance by establishing a "Transformation Fund" mechanism, which would involve all available funding (i.e., public-private partnerships, loan and world capital market sources). This Transformation Fund also aims to assist with market penetration. As such, at the initial phase, the ICCTF will be dominated by public funding and at the later stages will draw predominantly on private funds (Figure 3.4). The ICCTF can be accessed by sectoral ministries and other stakeholders to support the implementation of climate change programs. The coordination mechanism of the ICCTF is presented in Figure 3.5.

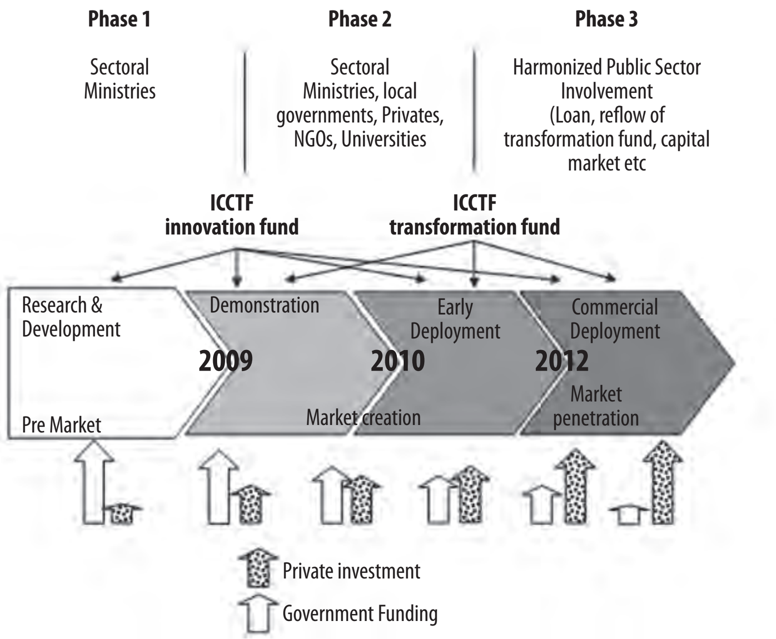


Figure 3.4 ICCTF development (BAPPENAS, 2009b)

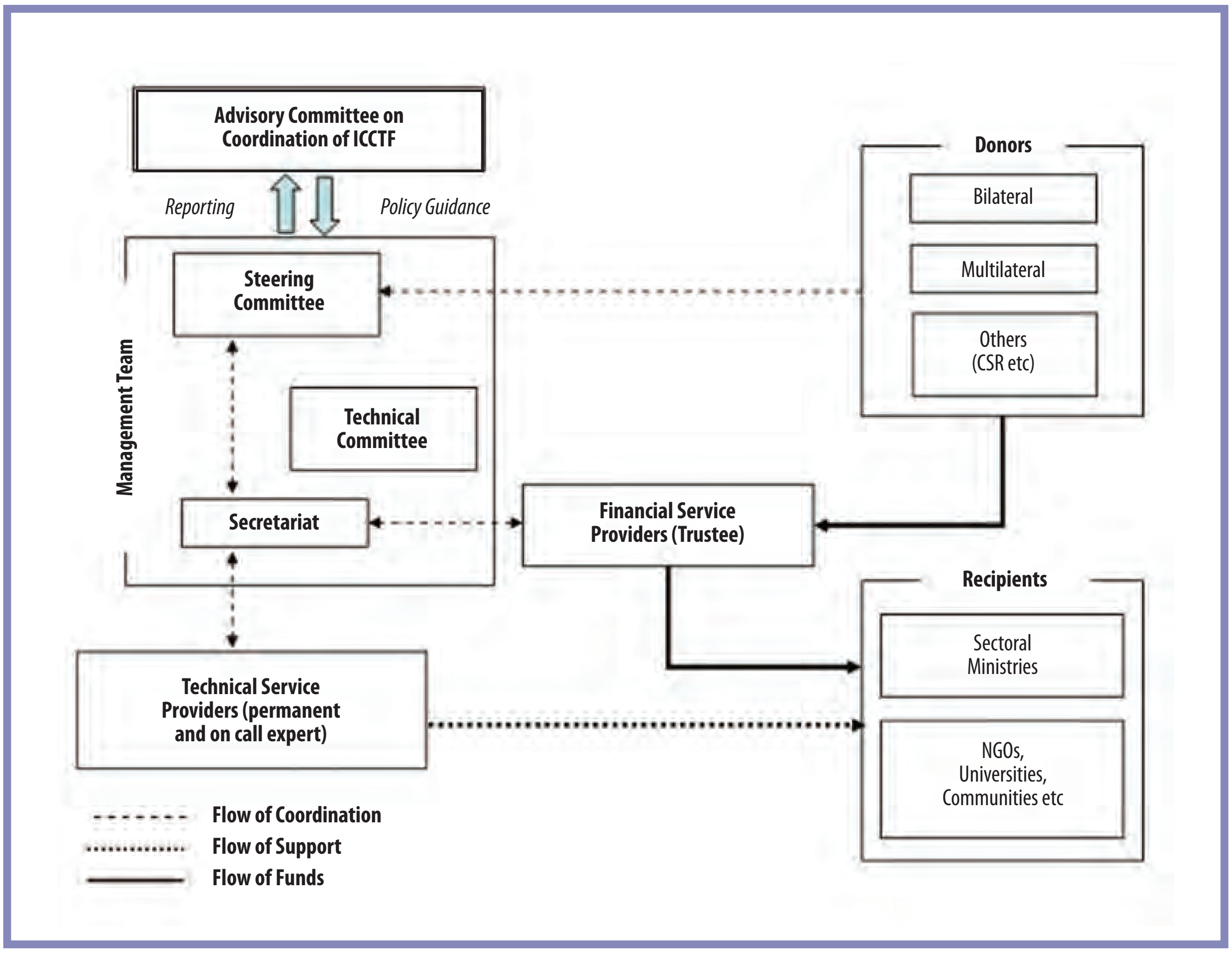


Figure 3.5 Coordination mechanism of ICCTF (BAPPENAS, 2009b)

CHAPTER IV

Measures to Facilitate Adequate Adaptation to Climate Change

4.1 Introduction

In the past four decades, climate-related hazards such as floods, droughts, storms, landslides and wildfires have caused major loss of human lives and livelihoods, the destruction of economic and social infrastructure, as well as environmental damage. In many parts of the world, the frequencies and intensities of these hazards have increased (Sivakumar, 2005; Asian Disaster Reduction Center [ADRC], 2005). Floods and windstorms accounted for 70% of all disasters during this period; droughts, landslides, forest fires, heat waves and others account for the remaining 30%. Between 2003-2005 alone, there were approximately 1,429 disaster incidences in Indonesia. About 53.3% of the disasters during that time period were hydro-meteorological disasters (BAPPENAS and Bakornas PB, 2006). Floods occurred most often (34% of the time), followed by landslides (16%). It is likely that global warming will lead to greater extremes of drying and heavy rainfall which will, in turn, lead to higher risk of climate hazards (Trenberth and Houghton, 1996; Intergovernmental Panel on Climate Change [IPCC], 2007). A 2006 report from UN Office for Coordination of Humanitarian Affairs (UN-OCHA) indicates that Indonesia is one of the countries vulnerable to climate-related hazards.

In the future, a changing climate brought about by global warming is expected to create new patterns of risk, and higher risks in general. Sea level rise due to melting glaciers and polar ice as well as thermal expansion will contribute to the increased risk of coastal flooding. Increasing intensity of tropical cyclones observed in recent decades may be tied to increasing sea surface temperatures (SSTs). By impacting the hydrologic cycle, global warming is expected to alter climatic ranges, shift regional climatic averages and climate zones, and lead to a higher frequency and amplitude of weather events. Climate variability and change occurring against a backdrop of increasing global population and globalization of economic processes may lead to increased competition over resources and new vulnerabilities (International Research Institute for Climate and Society [IRI] and Asian Disaster Preparedness Centre [ADPC], 2008). With the increased risk of climate-related hazards and disasters, many countries, particularly least developed and developing countries, may have difficulties achieving the UN Millennium Development Goals (MDGs) related to poverty, hunger and human health.

4.2 Historical Climate Change

The rapid increase in the concentration of greenhouse gases (GHGs) in the atmosphere has been determined to be the main factor causing global warming and climate change. IPCC (2007) reported that the global atmospheric concentration of carbon dioxide (CO_2) has increased from a pre-industrial value of about 280 parts per million (ppm) to 379 ppm in 2005. The atmospheric concentration of carbon dioxide in 2005 exceeds the natural range from the last 650,000 years (180 to 300 ppm) as determined from ice cores. Since the beginning of continuous direct atmospheric measurements (1960), it is clear that the annual growth of the carbon dioxide concentration in the atmosphere between 1995 and 2005 (1.9 ppm per year) was larger than that occurring between 1960 and 2005 (1.4 ppm per year), although there is a year-to-year variability in growth rates. The rapid increase of this gas has been the primary factor responsible for the global temperature increase (Figure 4.1).

Based on trend analysis of maximum and minimum temperature data from1980-2002 for 33 stations in Indonesia, a significant increase in maximum and minimum temperatures was observed in most of the stations (Boer *et al*., 2007). On average, the rate of changes in minimum and maximum temperatures across the 33 stations was 0.047^{O}C and 0.017^{O}C per year, respectively. In ocean waters surrounding Indonesia, in the period 1993-2008, the average rate of SST increase ranged from 0.020°C/year to 0.023°C/year (Sofian, 2010). The associated increase in global temperature caused an increase in sea level rise due to ice melting and thermal expansion of sea water. Based on analysis of altimeter data from January 1993 to December 2008, it was found that the rate of sea level rise ranged from 0.2 cm/year to 1 cm/year, with an average of approximately 0.6 cm/year (Figure 4.2).

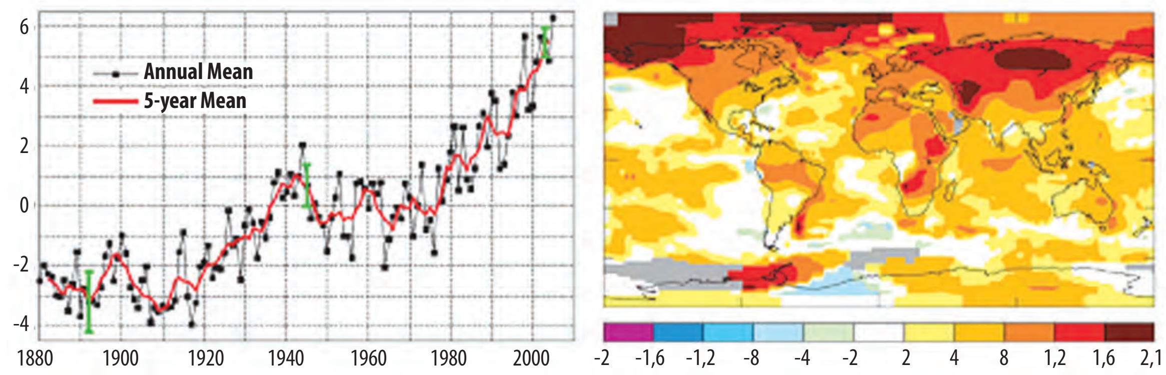


Figure 4.1 (a) Anomaly of mean global temperature of sea-land and (b) 2001-2005 mean surface temperature relative to 1951–1980 measured at meteorological stations and ship and satellite SST measurements (Hansen et al., 2006)

Global warming may lead to changes in regional climate, such as changes in precipitation (i.e., the amount of heavy rainfall) and in climate extremes, such as number of hot days and number of long dry spells. The effect of global warming will be superimposed on decadal climate variability, such as that caused by the inter-decadal or Pacific Decadal Oscillation (PDO), and on inter-annual fluctuations caused by the El Niño Southern Oscillation (ENSO) and the North Atlantic Oscillation (NAO) (Salinger, 2005). All this may lead to a century of increasing climate variability and change, expected to be unprecedented in the history of human settlement and agrarian activities.

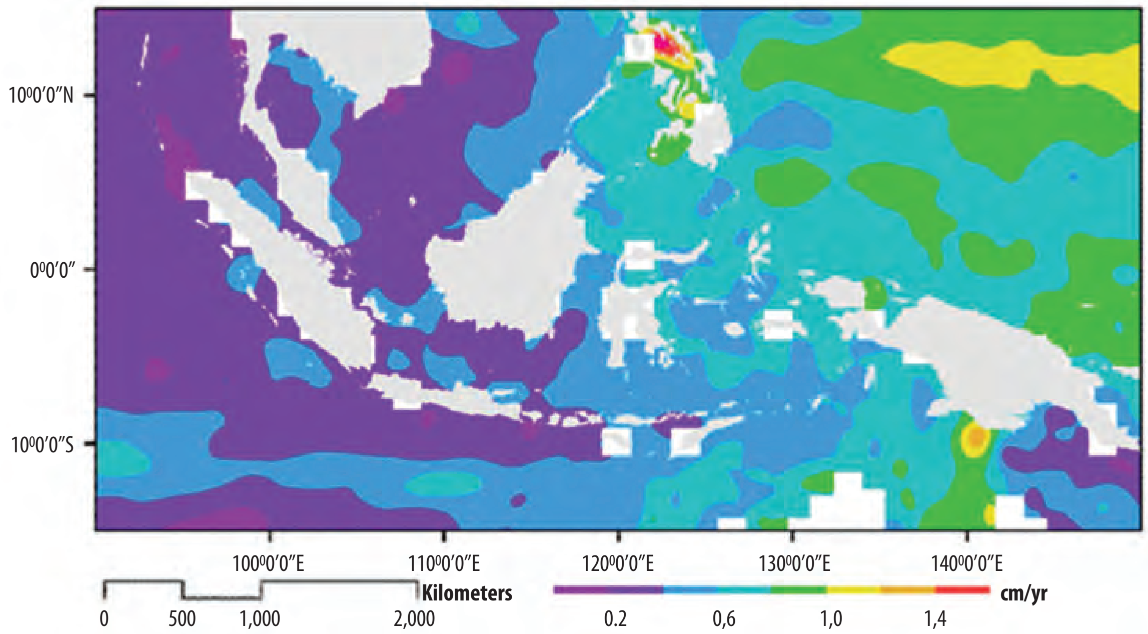


Figure 4 2 Sea level rise trends based on altimeter data from January 1993 to December 2008 (Sofian, 2010)

Based on trend analysis of historical rainfall data from 384 stations overtime scales between 20 and 50 years, significant decreases and/or increases in rainfall were detected in many parts of the Indonesian region. A significant decreasing trend in December-January rainfall was observed in small parts of Java, Papua, and Sumatra and over a large portion of the Kalimantan islands, where as a significant increasing trend was observed in most of Java and eastern Indonesia, including Bali, Nusa Tenggara Barat (NTB) and Nusa Tenggara Timur (NTT) (Figure 4.4a). For June-August rainfall l, significantly decreasing trends were observed in most of the Indonesian region with exceptions in Pandeglang (West Java), Makasar (South Sulawesi), Monokwari, Sorong (Papua) and Maluku (Figure 4.4b). The distribution of maximum rainfall during the wet and dry seasons also changed in some of the locations (Figure 4.3).

The monsoon onset has also changed in many parts of Indonesia. Based on analysis of data from 92 stations spread over Indonesia, the monsoon onset has been increasingly delayed in some parts of Indonesia, particularly in Java; similarly, the length of the wet season has tended to shorten, particularly in South Sumatra, Java and Kalimantan (Badan Meteorologi Klimatologi dan Geofisika [BMKG], 2005). Other studies conducted in East Java also suggest that the number of extreme dry months in the Brantas Catchment area has increased in the last five decades, particularly in areas near the coast (Aldrian and Djamil, 2006). In these coastal areas, the number of extreme dry months increased to 4 months during the last ten years and in 2002, the figure reached 8 months, a level considered as the longest dry season in five decades. In mountain areas, the number of dry months over the last ten years is 1-2 months, with a maximum number of 4 months.

4.3 Future Climate Change

Projecting climate into the future has great uncertainty, as the magnitude of change depends on many factors such as GHG concentration in the atmosphere and land use/cover changes. Changes in these factors depend on global socio-economic development and other human behaviors. The IPCC has projected different emissions scenarios and GHG concentrations in order to estimate the changes in the planet's climate. For Indonesia, two IPCC scenarios, SRESA2 and SRESB1, were selected as they reflect current understanding and knowledge about underlying uncertainties in the emissions. SRESA2 describes a very heterogeneous world. The underlying theme is self-reliance and preservation of local identities. Fertility patterns across regions converge very slowly, which results in a continuously increasing global population. Economic development is primarily regionally oriented and per capita economic growth and technological change are more fragmented and slow. SRESB1 describes a convergent world with the same global population that peaks in mid-century and declines thereafter, rapid change in economic structures toward a service and information economy, with reduction in material intensity and the introduction of clean and resource-efficient technology (IPCC, 2000). With these characteristics, the SRESA2 will lead to higher future GHG emissions while SRESB1 leads to lower future GHG emissions.

The impact of different levels of GHG emissions was assessed based on simulations from 14 General Circulation Models (GCMs). This analysis was used to evaluate the direction of rainfall change (either increasing or decreasing) suggested by the 14 GCMs. The level of confidence to a particular direction of change is considered to increased if most or all of the models are in agreement. From the analysis, a set of maps showing a change in seasonal rainfall under the two emissions scenarios (SRESA2 and SRESB1) are shown in Figures 4.5-4.8. Areas highlighted with dark red (value equal to 1) mean that all 14 GCMs suggest a decrease in future rainfall, while dark blue areas (values equal to 0) indicate that all the GCMs suggest an increase in future rainfall.

Figure 4.5 suggests that under increasing GHG emissions scenarios (i.e., SRESA2), most of the models are in agreement that in 2025 the wet seasonal rainfall (DJF) in Java, Bali, NTB, NTT and Papua will increase, while in other parts of Indonesia will decrease. By 2050 and 2080, most of the Indonesian region will experience higher rainfall than under the current condition, with exceptions in the northern parts of Sumatra and Kalimantan. Furthermore, dry season rainfall (JJA) in most parts of Java might decrease by 2025, increase again by 2050, and then decrease by 2080, particularly in West Java and South Sumatra. Under low emission scenarios (i.e., SRESB1), the pattern of change is similar to that of high emission scenarios, but the magnitude of change is slightly lower.

[2] DJF = December, January, February
[3] JJA = June, July, August

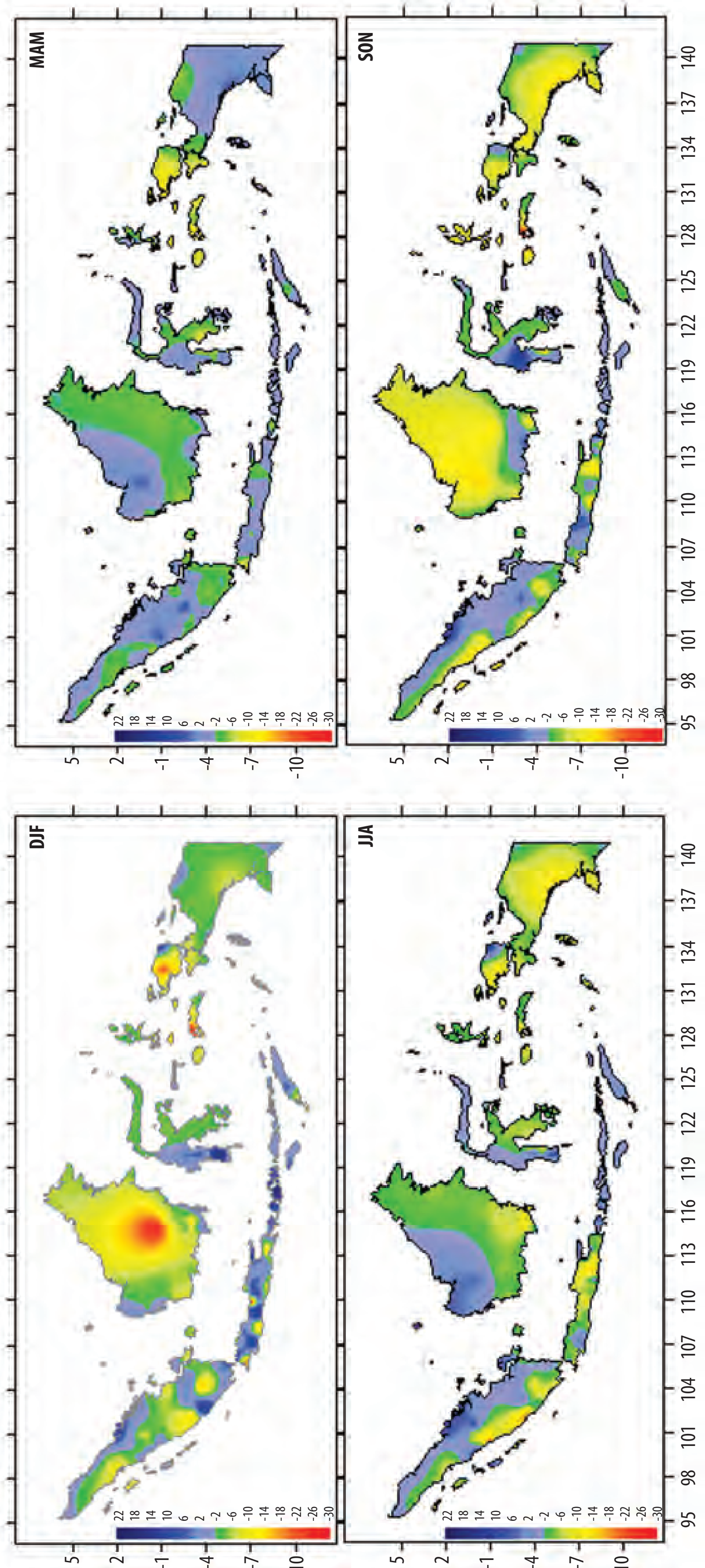


Figure 4.3 Seasonal rainfall trends (mm/year) for Indonesia (Boer et al., 2009)

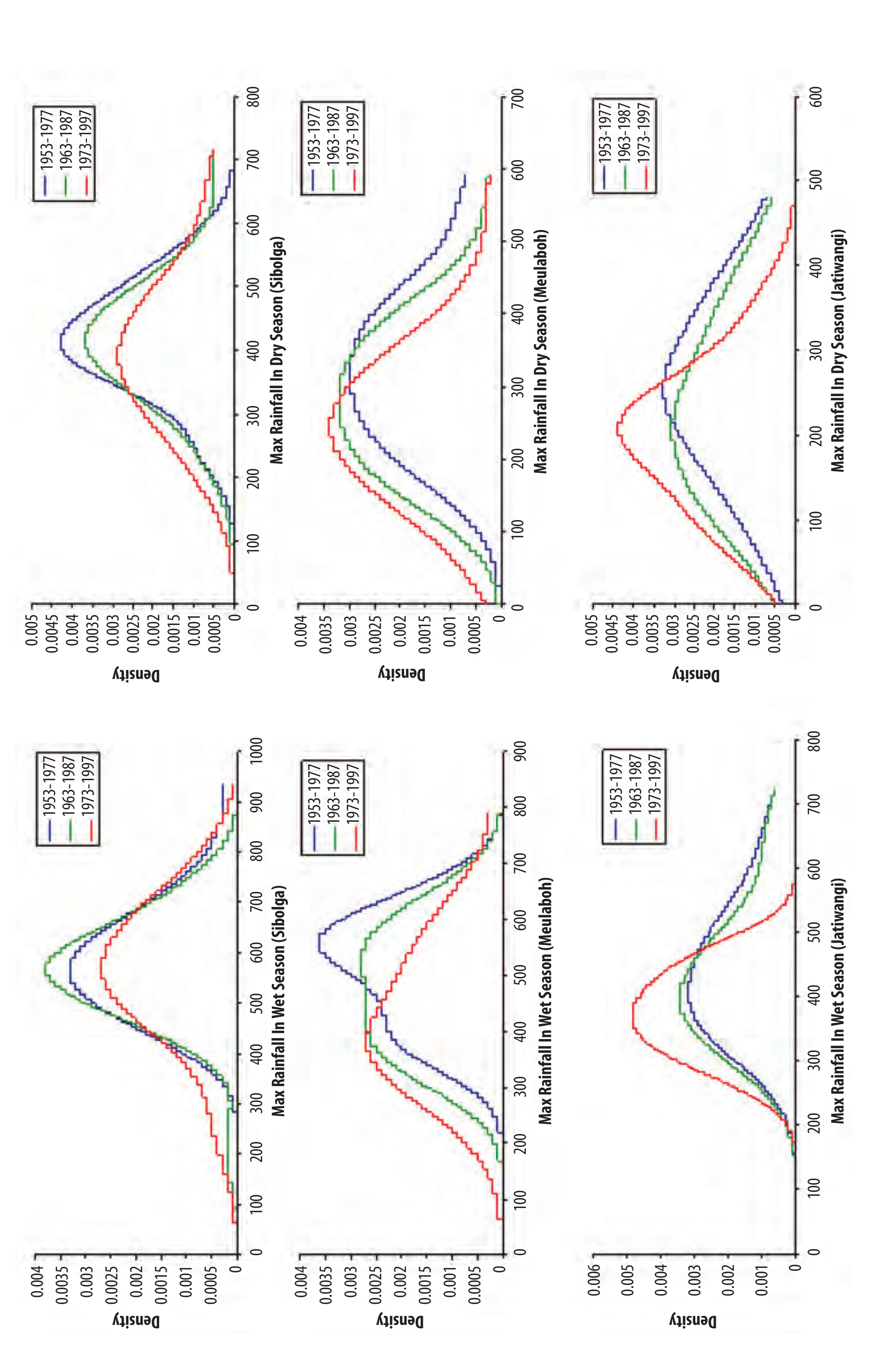


Figure 4.4a Distribution of maximum monthly rainfall during the wet and dry seasons in Sibolga-North Sumatra, Maulaboh-West Sumatra and Jatiwangi-West Java (Boer et al., 2009)

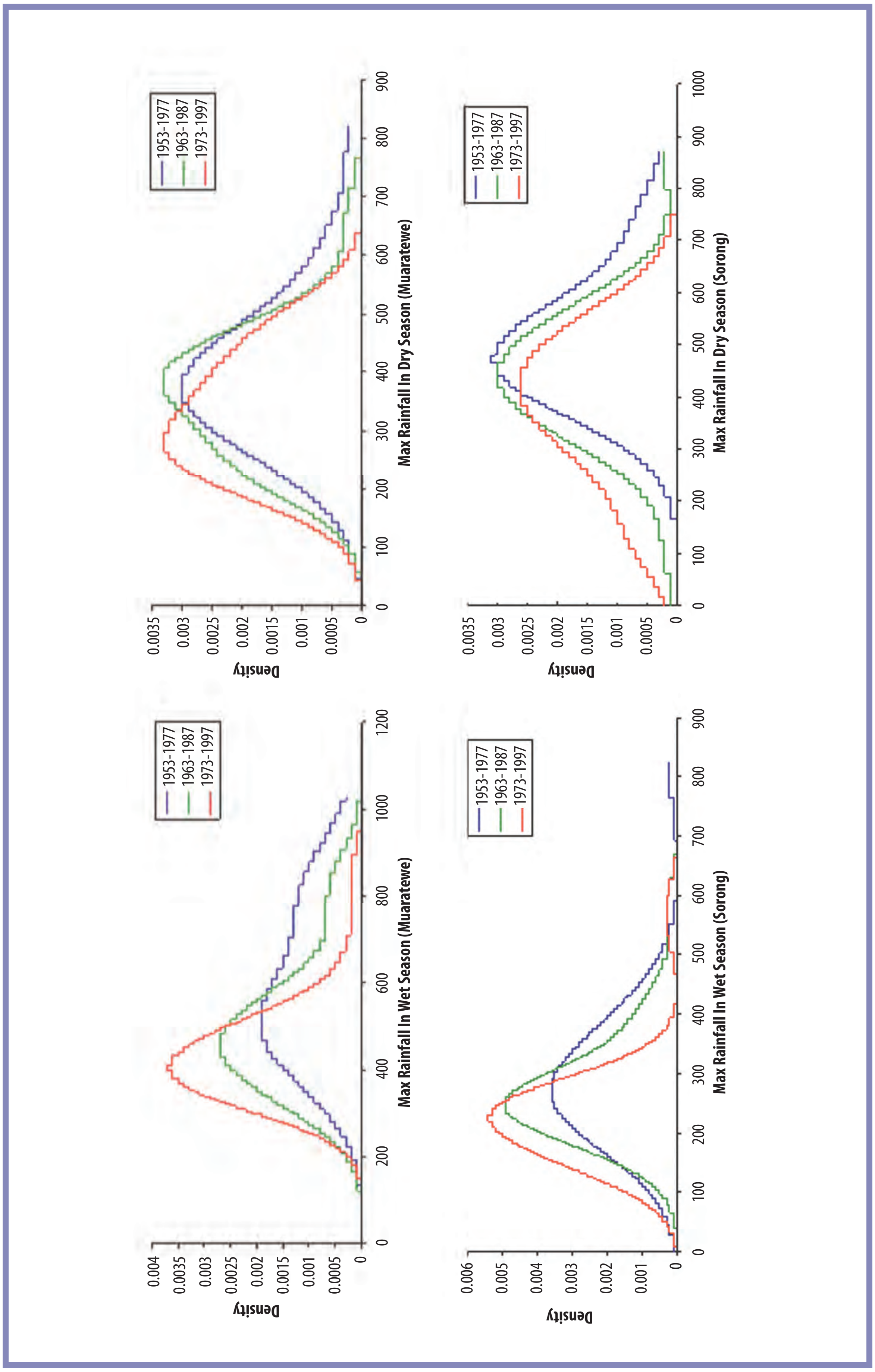


Figure 4.4b Distribution of maximum monthly rainfall (mm) during the wet and dry seasons in MuaraTewe-Central Kalimantan and Sorong-Papua (Boer et al., 2009)

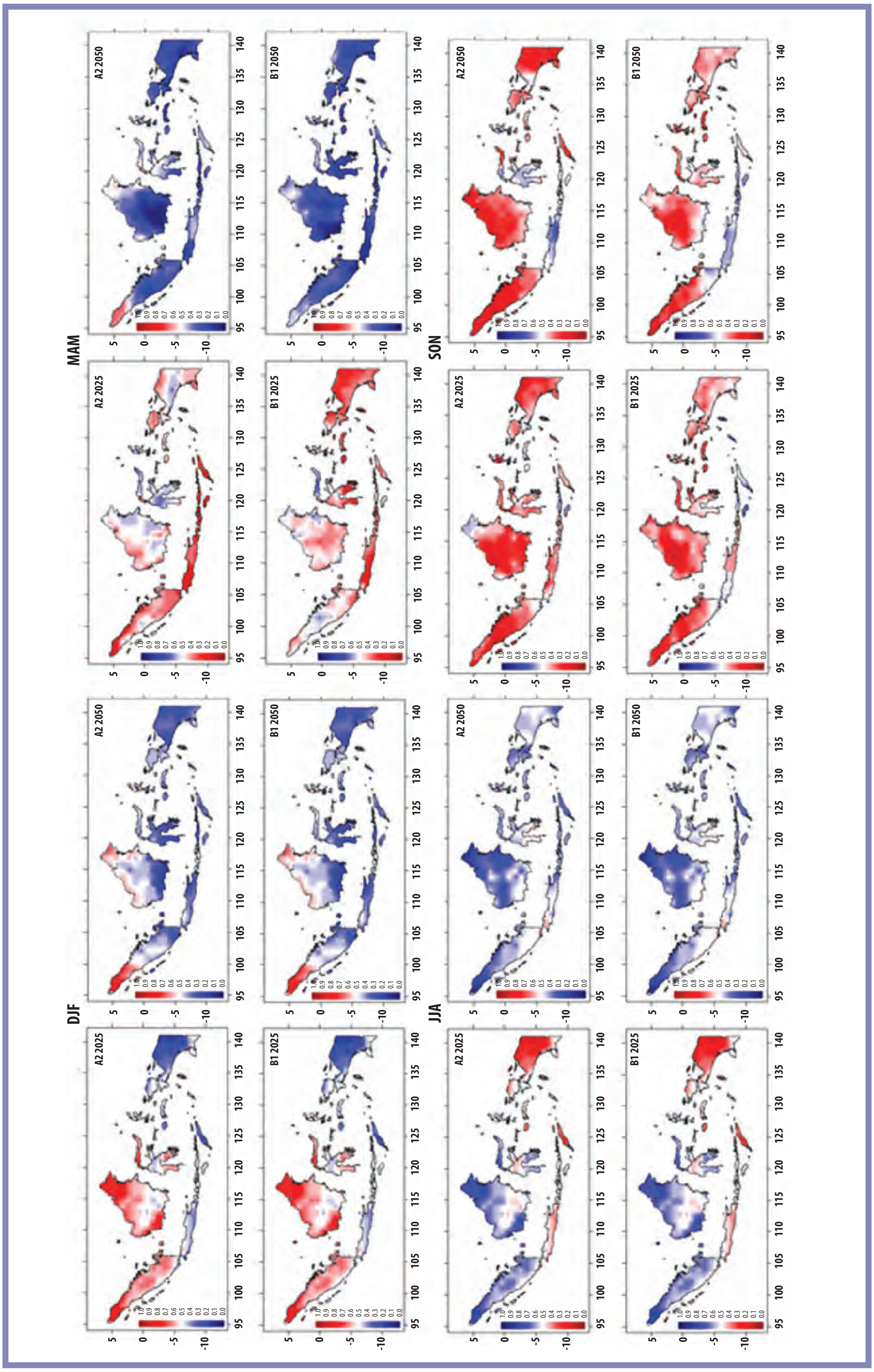


Figure 4.5 Level of probability for seasonal rainfall to change in the future (Note: rainfall in areas colored dark red will decrease in the future, and rainfall in areas colored dark blue will increase in the future with relatively high level of confidence (Boer et al., 2009

The impact of global warming on the monsoon onset in Java and Bali using more GCMs and empirical downscaling models was conducted by Naylor et al. (2007). It was found that under the SRESA2 scenario, total AMJ rainfall in Java and Bali is expected to increase relative to the current pattern by approximately 10% on average, but to decrease in JAS by about 10-25%. The decline in JAS rainfall could be up to 50% in West/Central Java and 75% in East Java/Bali at the tail end of the distributions. In East Java/Bali, some models projected that total rainfall would drop close to zero during JAS (Figure 4.6). Under SRESB1, the projection of changes is similar to those of SRESA2 until 2050. The shifted balances between the AMJ and JAS rainfall seasons will lead to the shifted onset of the wet and dry seasons. The onset of the rainy season in Java and Bali will be delayed under a changing climate (Figure 4.6). However, the uncertainty is quite high, as illustrated by the wide range of results among GCMs for a given empirical downscaling model (EDM) (Figure 4.6). Nevertheless, it is clear that a 30-day delay in monsoon onset is very likely to occur more frequently in 2050 than it does today.

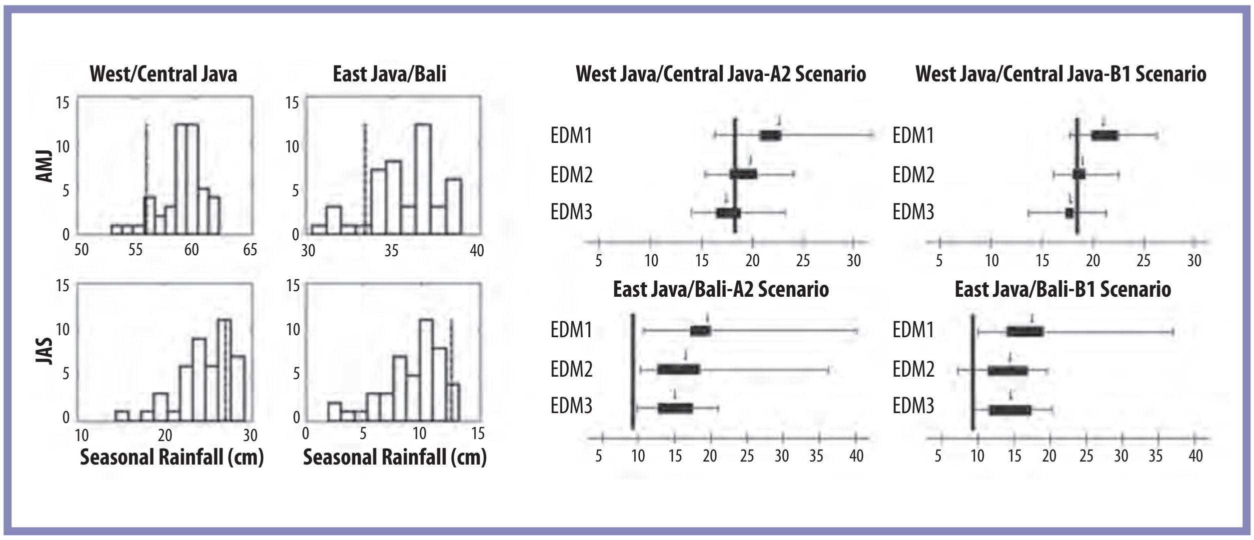


Figure 4.6 (a) Summed precipitation for AMJ and JAS for the present climate (dashed line) and for the future predicted climate, using the A2 scenario, and (b) Likelihood of exceeding the 30-day monsoon threshold in 2050. The thick rectangle shows the middle tercile, and the horizontal lines on either side show the lower and upper terciles. The arrows indicate the mean future probability for all GCMs. The vertical lines show the observed probability for 1983–2004 (Naylor et al., 2007). Note: The analysis was done using 15 different GCMs and 3EDMs

Many studies indicate that extreme climate events are often associated with the El Niño Southern Oscillation (ENSO). ENSO is one of the natural phenomena that has resulted in devastating consequences on rainfall and caused disasters in Indonesia. El Niño is often related to drought and La Niña to floods. Based on 43 drought events that occurred between 1844-1998, only six drought events were not associated with El Niño (Boer and Subbiah, 2005; Asian Development Bank [ADB] and BAPPENAS, 1999; Quinn *et al.*, 1978). Moreover, ENSO is considered as one of the overriding control factors in major forest/land fires and haze occurrence and frequency.

[4] AMJ = April, May, June
[5] JAS = July, August, September

Climate-related hazards in Indonesia are also caused by the location and movement of the tropical cyclones in the south eastern Indian Ocean (from January to April) and the eastern Pacific Ocean (from May to December). Essential for cyclone genesis are SSTs above 26.5°C, latitude beyond 5 degrees and small vertical wind shear. Since tropical cyclones have sustained surface winds of 32ms-1 or more, their impacts to the Indonesian region are commonly local strong winds and heavy rainfall on the order of hours to days. Strong winds also often occur during the transition from the northeast to southwest monsoon and vice versa. Many studies have also suggested that increasing SSTs will strengthen the tropical cyclones (Emanuel, 2005).

4.4 Climate Change Impacts and Adaptation Assessment

4.4.1 Agriculture

Historical data has indicated that the change in the onset of the wet season and in its length will influence rice production levels and cropping patterns in Indonesia. Rice is the major staple food in Indonesia. The delay of the wet season onset due to El Niño phenomena causes decreasing cumulative cropping area during wet season (MH). Naylor *et al.* (2007) found that a one month delay in wet season onset due to El Niño phenomena would decrease wet season rice production by approximately 65% for West Java and Central Java and 11% for East Java and Bali. This decreasing cropping area during the wet season will usually be compensated by increasing the cropping area during the dry season (MK) which generally has a high risk of experiencing drought (Figure 4.7), except when El Niño phenomena turns into La Niña conditions (Figure 4.8). Significant decreases in rainfall during the dry seasons in El Niño years also affects the production of other national food crops. However, the effect is not as significant compared to the effects on rice crops.

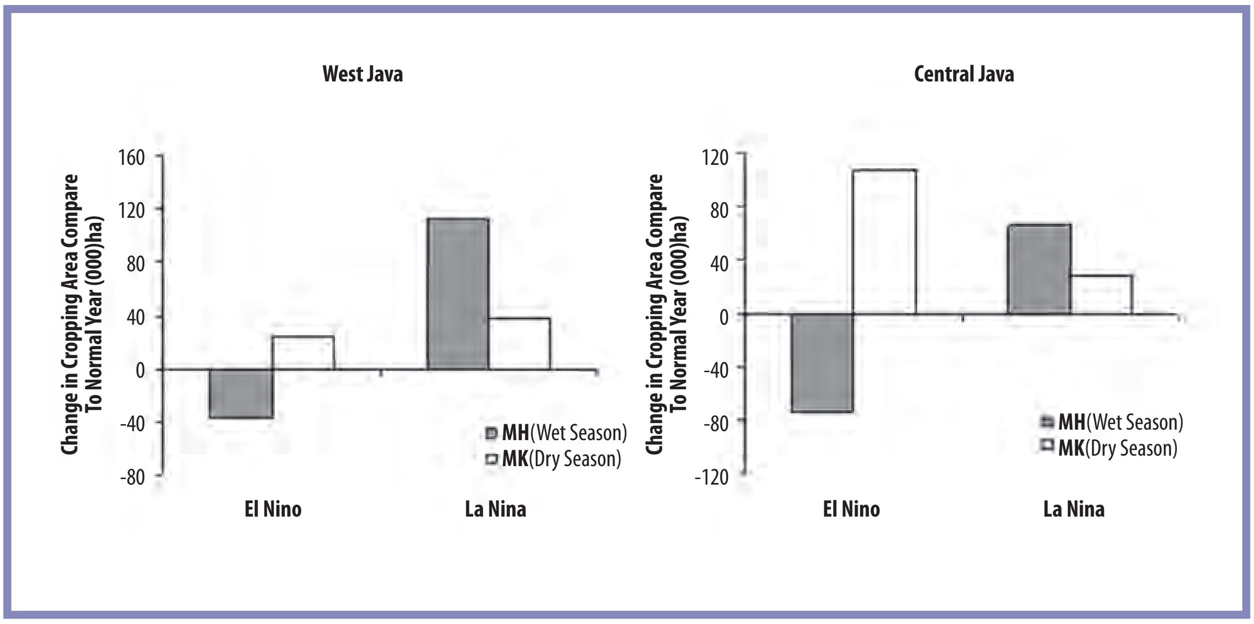


Figure 4.7 Change in cumulative cropping area in the wet season (MH) and dry season (MK) during ENSO years (El Niño and La Niña) compared to normal years (Boer, 2009)

Long dry seasons during El Niño years significantly affect not only annual crops, but also perennial crops. Based on field observations, a long dry season generally destroys young plants. During the 1994 El Niño for example, the percentage of young plants (age of less than 2 years) die back due to the long dry season could go up to 30%. Based on observations in a number of locations, the average young plant dieback for tea crops was approximately 22%, between 4% and 9% for rubber, about 4% for cacao, between 1.5% and 11% for cashew nuts, about 4% for coffee and between 5% and 30%for coconut. For mature plantation crops such as coconut and palm oil, the impact of severe drought appears after 4-9 months (Hasan *et al.,* 1998).

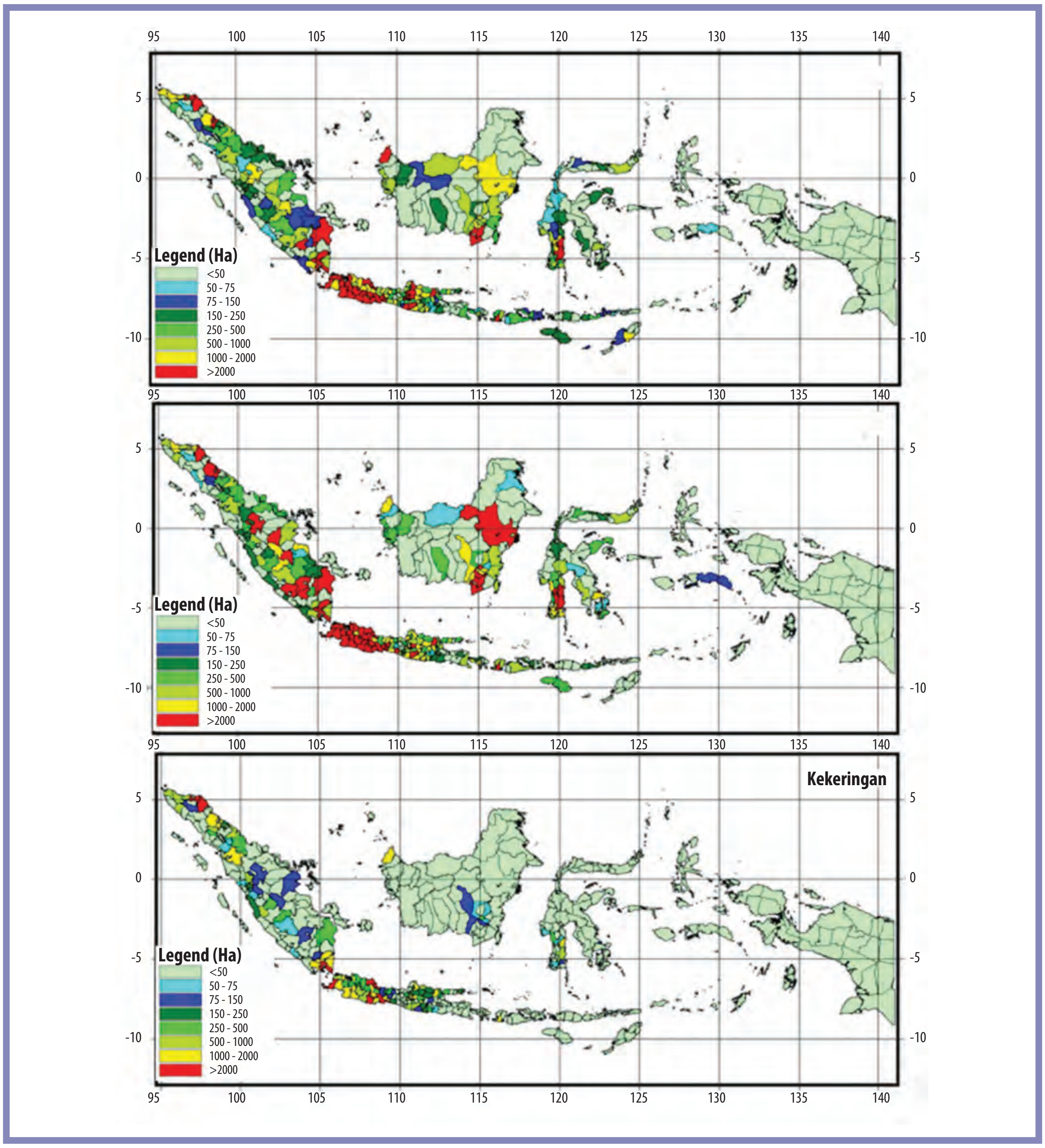


Figure 4.8 Mean area of dry season rice affected by drought from 1989-2006 (above), during El Niño years (middle) and La Niña years (bottom). Source: Boer (2009)

The dynamic interactions of crop pests and diseases on crops also appear to be related with ENSO. Rice growing area destroyed by brown plant hopper ('wereng coklat') tended to increase significantly during LaNiña years. For example, in West Java, the total area destroyed by this pest during 1998 LaNiña could increase up to 80 times the size of the area lost during normal years. In addition, there is an indication that types of major crop pests and diseases have shifted recently. Historically, pink rice stem borer (Sesamiainferens), for example, was only a minor problem in Java (e.g.,Indramayu, Magelang, Semarang, Boyolali, Kulonprogo, and Ciamis) compared to yellow rice stem borer (Scirpophaga incertulas) and white rice stem borer (Scirpophaga innnotata). Today, this disease has become dominant (Nastari Bogor and Klinik Tanaman Institut Pertanian Bogor [IPB], 2007). According to Kalshoven (1981), regions with distinct dry seasons are favorable for pink rice stem borer. Bacterial leaf blight (Xanthomonas oryzae pv. Oryza) in the last three years has also become one of the dominant rice crop diseases when historically, this disease was not important. Saddler (2000) stated that the optimal temperature for growth of this disease is around 30oC.

Similar phenomena has also been observed in non-rice crops. Prior to 1997, twisting disease caused by Fusarium oxysporumwas not an important disease for red onion crops, but now this is a very important disease not only in lowland areas, but also in the highlands. In the last two years, this disease has seriously attacked red onion crops in a number of onion production centers such as Brebes (Wiyono, 2007). From laboratory research, when being exposed to high temperatures, this crop becomes less resistant to this disease (Tondok, 2003). The phenomenal example is the appearance of Gemini disease in chili in the last five years in all main chili and potato production centre of Java (Bogor, Cianjur, Brebes, Wonosobo, Magelang, Klaten, Boyolali, Kulonprogo, Blitar, and Tulungagung; Nastari Bogor dan Klinik Tanaman IPB, 2007). This disease caused by virus which is transmitted to the crops by kutu kebul (Bemisiatabaci). It is not clear whether these phenomena are related to global warming. However, many researchers found that the main triggering factor for the crop disease to proliferate is temperature increase. For example, a significant increase in Bemisiatabaci populations on tomato occurred when the temperature increased from 17 to 30°C (Bonaro et al., 2007). The explosion of this virus under elevated temperature has been predicted by Boland et al., (2004) in Canada.

Changes in rainfall and increases in temperaturewill bothdirectly and indirectlyaffect dairycattleproduction and reproduction performance. The direct impacts are the effects on production and their reproduction systems, while the indirect impacts aredue to impacts on the quality and quantity of grass or forage needed for livestock feed. Feed shortages limit the dry matter and nutrient intake of the animal resulting in low productivity, reduced reproductive performance, increased mortality rates, increased culling rates and changes in the population of the animal in some regions. High temperatures may have negative impactson dry matter intake, milk yield, growth rate, resistancy of the animal to diseases and reproductive performance of dairy cattle. A decrease in dry matter intake in dairy cattle during highambient temperatures is main factor reducing productivity of dry cattle.

Based on a study conducted in Java, rainfall and temperature (defined in the form of a "comfort index") affect length of the pregnancy period (PP) and interval of birth of sheep (Rohman and Boer, 2001). Sheep raised in regions with lower annual rainfall and higher temperatures tended to have a longer pregnancy period. The interval between two births (BI) was also found to be longer (Figure 4.9). The comfort indices for PP and BI are expressed by the following equations:

CIPP = -0.00044 R + 0.54889 Tand CIBI = -0.00145 R + 1.08133 T, where R and T are annual rainfall and mean annual temperature, respectively.

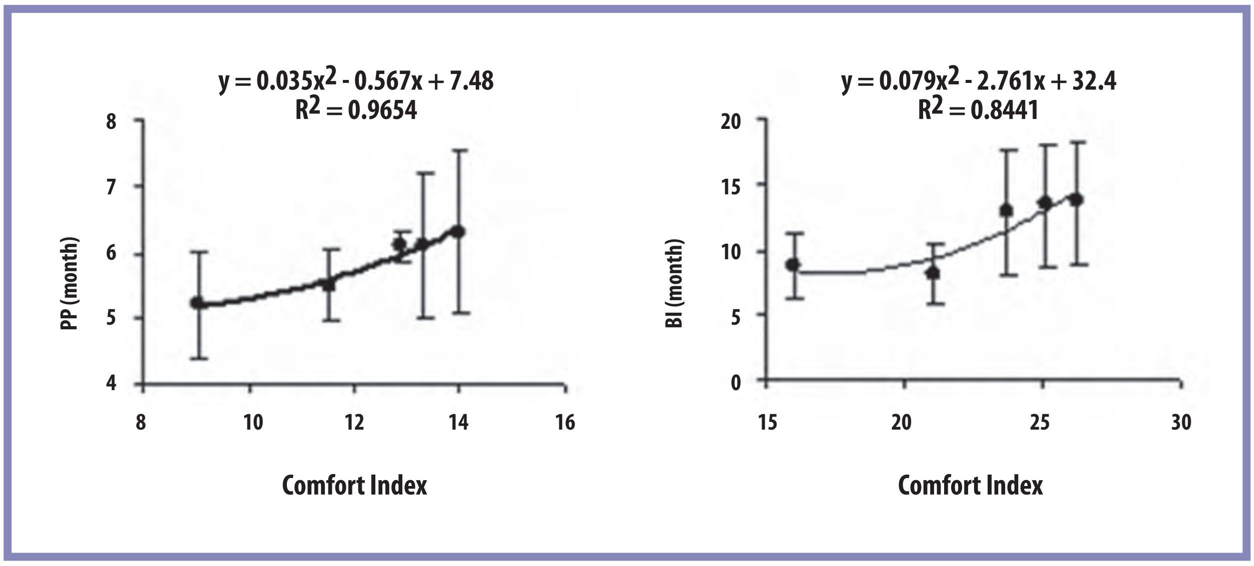


Figure 4.9 The relationship between comfort index and length of pregnancy period (left) and comfort index and interval between two births (right).Source: Rohman and Boer, 2001

The increase in temperatures due to elevated CO_2 levels also affects crop yields. Based on a simulation study conducted in Java (Boer *et al.*, 2009), it was found that the negative effect of increasing temperatures on rice yield will reduce if increases in CO_2 concentration considered. The increase of CO_2 from 370 to480 ppm (SRESB1) or 520 ppm (SRESA2) can eliminate the negative effects of increased temperatures. In some districts, rice production in 2025 and 2050 would actually be higher from the current production rate. However, in general, total rice production in Java will experience a decrease from increasing temperatures with or without considering the positive effects of CO_2. When the effect of CO_2 was not considered without any technology intervention, the decrease in rice production in Java by2025 and 2050 could reach 1.8 and 3.6 million tons, respectively; when the effect of CO_2 was considered, the decrease in rice production is 33,964 tons and 59,584 tons in 2025 and 2050, respectively, for SRESA2 and 39,3048 tons and 88,8230 tons in 2025 and 2050, respectively, for SRESB1 (Table 4.1)

Table 4.1 Decrease in rice production in Java compared to current production as increasing temperature and CO_2 concentration in Scenario1 (Boer et al., 2009)

Province	Increasing CO_2 not considered		Increasing CO_2 considered			
			SRESA 2		SRESB1	
	2025	2050	2025	2050	2025	2050
West Java	-620,389	-1,207,728	-22,311	-33,034	-142,034	-309,315
Central Java	-609,644	-1,180,292	-27,132	-36,170	-143,739	-305,261
East Java	-597,734	-1,194,802	15,479	9,620	-107,274	-273,653
Total	**-1,827,767**	**-3,582,822**	**-33,964**	**-59,584**	**-393,048**	**-888,230**

Note: The calculations were based on existing planting area (see Table 4.2) and cropping index (see Table 4.3). Values are expressed in tons.

The decrease in crop production is due not only to climatic factors, but also non-climatic factors. By taking into account the impact of non-climatic factors in the analysis, it will provide better understanding of future crop production under changing climate. Boer *et al.* (2009) introduced three non-climatic factors in assessing impact of climate change in Java – paddy field conversion to non-agriculture land area, cropping index, and technology intervention. Based on these factors, the following six scenarios were evaluated:

1. **Scenario 1:** In the future, there is no rice field conversion in Java, and no change in cropping index. Therefore, in this case, the change in the rice production is only affected by climate change and changes in CO_2 concentration.
2. **Scenario 2:** The rate of rice field conversion was assumed 0.77% per year, while cropping index is constant or unchanged.
3. **Scenario 3:** No rice field conversion occurs in the future, however, the cropping index is increased from the current condition. In this study, the cropping index (CI) of rice in West Java increased to 2.30 and 2.10 in Central Java and East Java by 2025. By2050, the IP increases significantly to 2.50 in West Java, 2.30 in Central Java and 2.20 in East Java. The current cropping index (CI0) was estimated using the data of harvested area during the wet season (LPMH) and dry season (LPMK) because the standard data of cultivated area and rice field area was not available. The equation for estimating IP is as follows:

$$CI_0 = \frac{LP_{MH} + LP_{MK}}{LP_{MH}}$$

4. **Scenario 4:** The rate of rice field conversion is equal to Scenario 2 and the cropping index increases to that of Scenario 3.
5. **Scenario 5:** Like scenario 3,but crop productivity is assumed to increase in intervals of 5%, 10%, 15%, 20%, 25% and 30% with the invention and implementation of agronomy technology.
6. **Scenario 6:** Like scenario 4, but crop productivity is assumed to increase in intervals of 5%, 10%, 15%, 20%, 25% and 30% as existence of intervention of agronomy technology.

The projected decrease in rice production due to agricultural land conversion is much greater than the decrease due to increasing temperatures. By using a rice field conversion rate of 0.77% per year and no change in the cropping index used in Scenario 2, rice production will decrease by 2025 and continue to decrease by 2050 compared to current production. Total decreased rice production in Java will reach 6 million tons by 2025 and will be more than 12 million tons by 2050. When the effects of CO_2 are considered in the model, rice production decreases by more than 5 million tons by 2025 and by more than 10 million tons by 2050 (Figure 4.10). The total rice field area in 2025 and 2050 using a rice field conversion rate of 0.77% is presented in Table 4.2.

Table 4.2 Total paddy field area (ha) in three provinces in Java for 2025 and 2050 using a rice field conversion rate of 0.77% per year (Scenario 2)

Province	Current	2025	2050
West Java	1,158,945	998,315	775,218
Central Java	1,053,889	907,820	704,947
East Java	1,238,335	1,066,702	828,322
Total	3,451,169	2,972,837	2,308,487

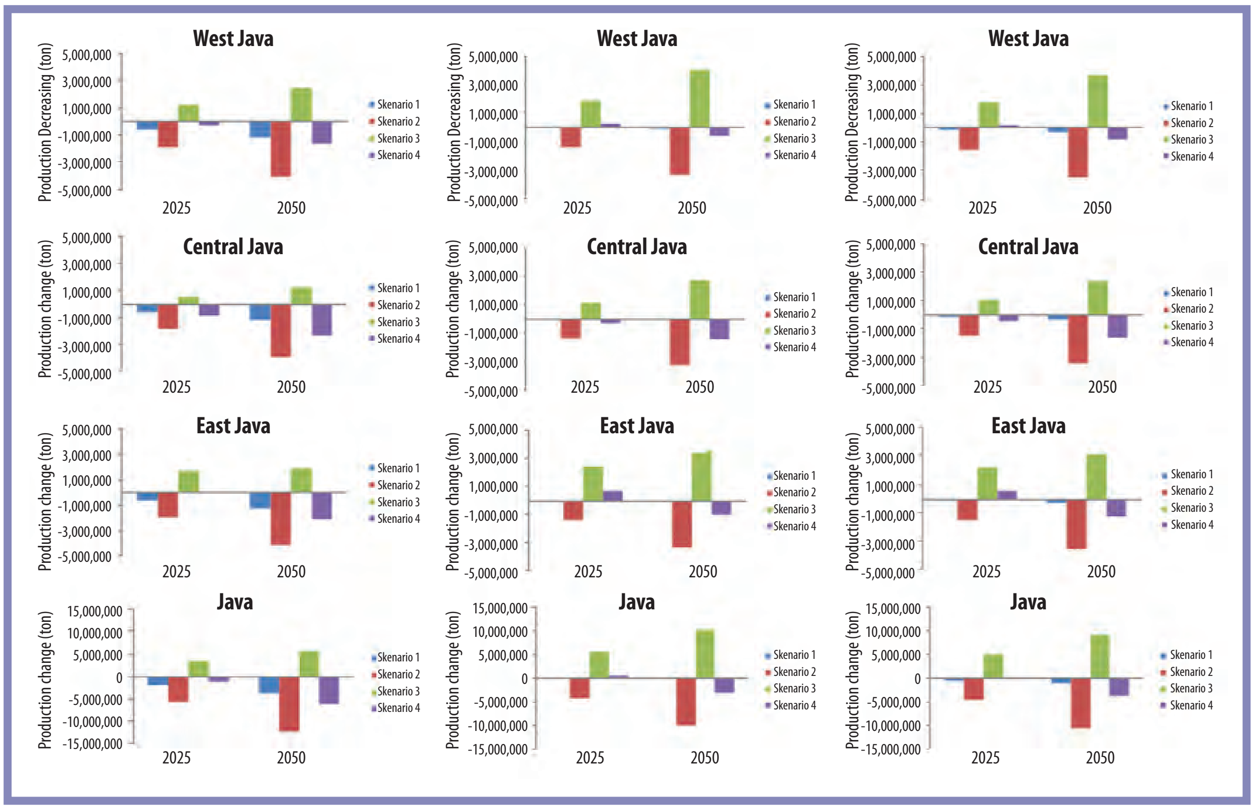


Figure 4.10 Changes in rice production in Java by 2025 and 2050 compared to current rice production due to increasing in temperatures and CO2 concentrations for SRESB1 and SRESA2 using various cultivated area values and planting indices (Boer et al., 2008)

Moreover, when rice field conversion does not occur in Java, the negative effects of increased temperature on rice production can be reduced by increasing cropping index. By using the assumption that the cropping index can be increased following the scenarios defined in Table

4.3, the rice production rate in most districts in Java by 2025 and 2050 are remain stable or even increase compared to the current production rate, with exceptions in the Tulungagung, Kediri, Purworedjo, Wonosobo, Magelang, Sleman, Klaten and Sukohardjo districts. However, when the effects of CO_2 are considered in the simulation model, the negative effects of increasing temperature on the decrease in rice production in these districts is not projected to occur in 2050.

Table 4.3 Cropping index scenario for rice in three provinces in Java for 2025 and 2050 (Boer et al., 2008)

Province	Current	2025	2050
West Java	1.70	2.10	2.50
Central Java	1.79	2.00	2.30
East Java	1.62	2.00	2.20

As shown in Figure 4.10, the decrease in rice production of Java by 2025 and 2050 is mainly due to land conversion and by climate change. Efforts to increase CI to maximum levels cannot maintain the current production in 2025 and 2050. This study suggests that loss of rice production due to increasing temperatures and land conversion in Java in 2025 and 2050 cannot be compensated by increasing CI only. On the other hand, the effort to increase CI following the scenario presented in Table 4.3 is hardly possible when the source of irrigated water is not from reservoirs.

The water source for irrigated rice is mostly not from reservoir. If CI for irrigated rice in which the water source comes from reservoir must be increased to 2.75 and not from reservoir also must be raised to 2.0 in West Java, and 1.8 in both Central Java and East Java require the development of new reservoir . Otherwise, CI can only increase to 2.2 for West Java, 2.0 for Central Java and optimal (e.g., 1.8) for East Java. If the scenario in Table 4.4 is reached, the number of reservoirs in Java should increase, so that the percentage of irrigated rice from reservoirs becomes 65% in West Java, 50% in Central Java and 40% in East Java (Figure 4.11).

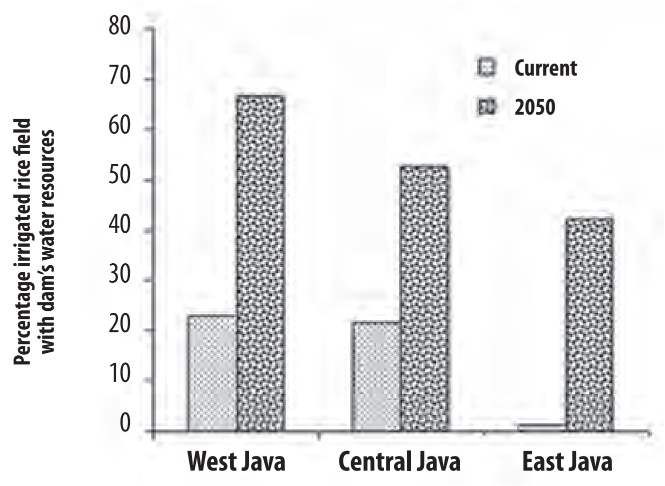


Figure 4.11 Percentage of irrigated rice fields from reservoir by increasing CI to 2.5 for West Java, 2.3 for Central Java and 2.2 for East Java (Boer et al., 2008)

Another effort to maintain the current rice production level of Java in 2025 and 2050 is through increasing crop productivity by improvement of agronomy such as fertilizer application or improvement of variety. When the effects of CO_2 are not considered, land conversion still occurred and CI increased (Scenario 5), hence, the current level of rice production can be maintained in 2025 by increasing the productivity level by 5%. By 2050, the level of productivity should be at least 25% higher from the current productivity level. When CI cannot be increased (Scenario 6), the level of productivity should be increased by 22% to maintain the current production level in 2025. By 2050, the level of productivity should be increased by 70% to maintain current levels of production (Figure 4.12).

Furthermore, when the effects of CO_2 are considered, the increase in productivity is not necessary to maintain current production levels in 2025. Meanwhile, increasing productivity from 10% to 15% is still required to maintain production level equal to the current production level in 2050. In Scenario 6, if CI is unchanged and land conversion still occurred, the levels of productivity in 2025 and 2050 would have to increase approximately 10% and 50%, respectively, to maintain current production levels. The level of rice productivity in 2025 and 2050 for Scenarios 5 and 6 are presented in Tables 4.4 and 4.5, respectively.

Table 4.4 Productivity levels (t/ha) require to maintain current production levels in 2025 and 2050 under Scenario 5 (CI increased and land conversion occurred; Boer *et al*., 2008)

Season	Province	Rice Production						
		Current Production (t/ha)	CO_2 ignored		CO_2 considered (SRESA2)		CO_2 considered (SRESB1)	
			2025	2050	2025	2050	2025	2050
Wet Season	West Java	4.70	4.94	5.97	4.70	5.17	4.70	5.31
	Central Java	5.14	5.40	6.53	5.14	5.66	5.14	5.81
	East Java	5.15	5.41	6.54	5.15	5.66	5.15	5.82
Dry Season	West Java	4.86	5.11	6.18	4.86	5.35	4.86	5.50
	Central Java	5.11	5.36	6.48	5.11	5.63	5.11	5.77
	East Java	4.88	5.13	6.20	4.88	5.37	4.88	5.52
Average		4.97	5.22	6.32	4.97	5.47	4.97	5.62

Table 4.5 Productivity levels needed maintain current production in 2025 and 2050 under Scenario 6 (CI constant and land conversion occurred)

Season	Province	Rice Production						
		Current Production (t/ha)	CO_2 ignored		CO_2 considered (SRESA2)		CO_2 considered (SRESB1)	
			2025	2050	2025	2050	2025	2050
Wet Season	West Java	4.70	5.74	7.99	5.55	6.96	5.55	7.24
	Central Java	5.14	6.27	8.74	6.07	7.61	6.07	7.92
	East Java	5.15	6.28	8.75	6.07	7.62	6.07	7.93
Dry Season	West Java	4.86	5.93	8.27	5.74	7.20	5.74	7.49
	Central Java	5.11	6.23	8.68	6.02	7.56	6.02	7.86
	East Java	4.88	5.96	8.30	5.76	7.23	5.76	7.52
Average		4.97	5.22	6.32	4.97	5.47	4.97	5.62

As previously discussed, increasing CI following the scenarios in Table 4.3 is difficult to attain. Therefore, rice field conversion rate in Java should be minimized if not prevented. In addition, the development of sustainable food crop land, as stated in Act No. 41/2009 about Protecting Sustainable Food Agricultural Land, is necessary to speed up actions for protecting land conversion.

If land conversion in Java is unavoidable and still occurred at a rate of 0.77% per year, and CI is constant (Scenario2), the development of irrigated rice fields should be developed outside Java to compensate for the loss in production in Java. The expanding irrigated area needed is approximately 1.3-1.8 million ha in 2025 and 3.0-3.8 million ha in 2050 (Figure 4.12).

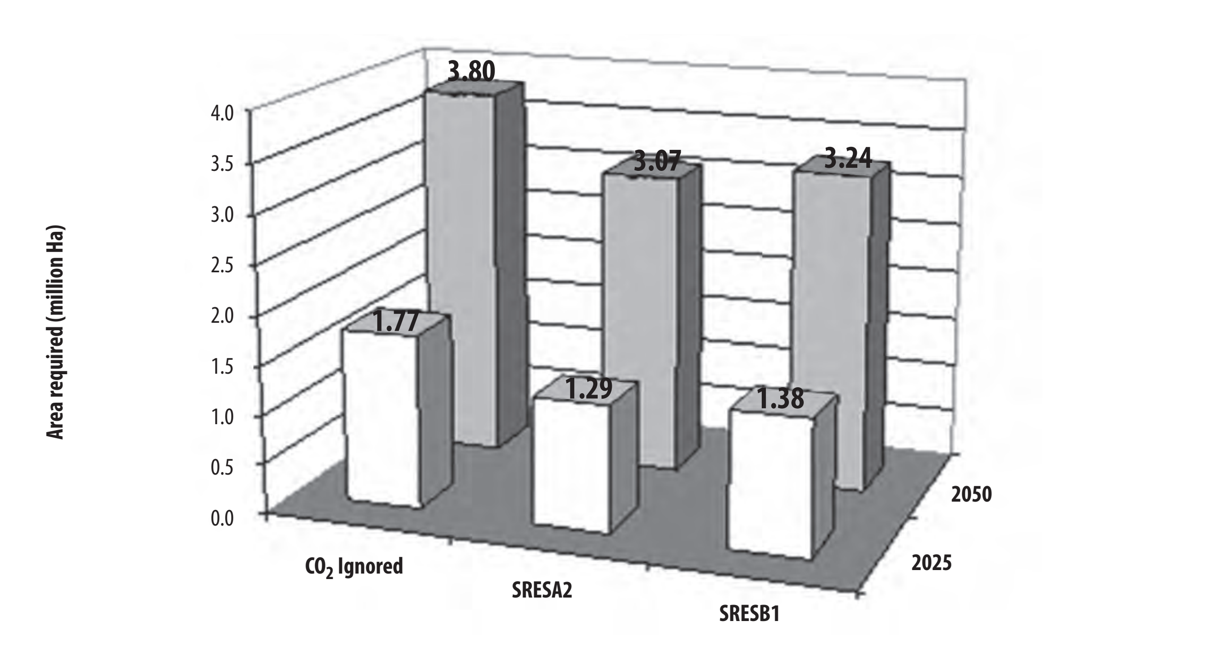


Figure 4.12 Expansion of irrigated area to compensate the loss of rice production in Java due to climate change and land conversion where increasing CI is not feasible. Source: Boer *et al.* (2008)

A rapid assessment conducted by Parry *et al.* (1992) in a number of locations in Indonesia suggested that sea level rise due to global warming will also reduce local rice supply in the Krawang and Subang districts by approximately 300,000 tons. Similarly, maize output would likely be reduced by 10,000 tons – approximately half of this is attributed to inundation. Sea level rise would also be likely to affect fish and prawn production. The loss is estimated to be over 7,000 tons and 4,000 tons, respectively (valued at over US$ 0.5 million). In the lower Citarum Basin, sea level rise could result in the inundation of 26,000 ha of ponds and 10,000 ha of crop land. This could result in the loss of 15,000 tons of fish, shrimp and prawns and approximately 940,000 tons of rice. Parry et al. stated that the socio-economic implications of this transition in the Subang District alone could be the loss of employment for about 43,000 farm laborers. In addition, more than 81,000 farmers would have to look for other sources of income due to the inundation of their rice fields or prawn and fish farms due to sea level rise.

Climate change is a long term threat that must be anticipated because of its adverse effects to the sustainability of agriculture. The Ministry of Agriculture has formulated the concept and strategic steps to cope with the threats. General strategy of adaptation for agriculture sector is focussing on food crops sub-sector in order to strengthen and sustain national food security. Some of the policy and strategy include:

a. Reforming the regulations and agricultural institutions in form of Ministrial Decrees
b. Development of information system, advocation, and communication
c. Development of agricultural insurance system related to climate change impacts (drought, flood, pest and diseases)

Some of the important adaptation program on most vulnerable sub-sectors (food crop and horticulture) to the adverse affects of climate change among others are:

a. Improvement of water management, irrigation scheme, soil and fertilization management including organic fertilizer and development of carbon efficient farming
b. Development of early, drought, salinity and inundation tolerant crop varietes
c. Development of farming risks insurance against adverse climate
d. Cropping pattern adjustment by preparation and dissemination of guidance and tools as dynamic cropping calendar and flood and drought naticipation blue print

Others strategic program to cope with climate change among others are development of climate field schools and system of rice intensification in all food crop production centers

4.4.2 Water Resources

To evaluate the impact of climate change on water resources, analysis based on River Area Unit (Satuan Wilayah Sungai, or SWS) was conducted in order to assess the change of water deficit duration under current and future climate. The water balance model is defined as follows:

$$Supply = Demand + Surplus$$

If the demand is higher than the supply, the surplus becomes negative and vice versa. Water supply is a function of monthly rainfall (Rmonthly) and forest cover. The forest cover will determine the fraction of rainfall that cannot be utilized (f). The formula for estimating the supply is as follows:

$$Supply = Rmonthly x (1-f)$$

The fraction of rainfall that cannot be utilized (f) range from 20% to 60% depending on percent forest cover (Figure 4.13). With the increase of forest cover, the fraction of unutilized rainfall will decrease. The f value was determined using the Tank model tested in a number of watersheds in Java.

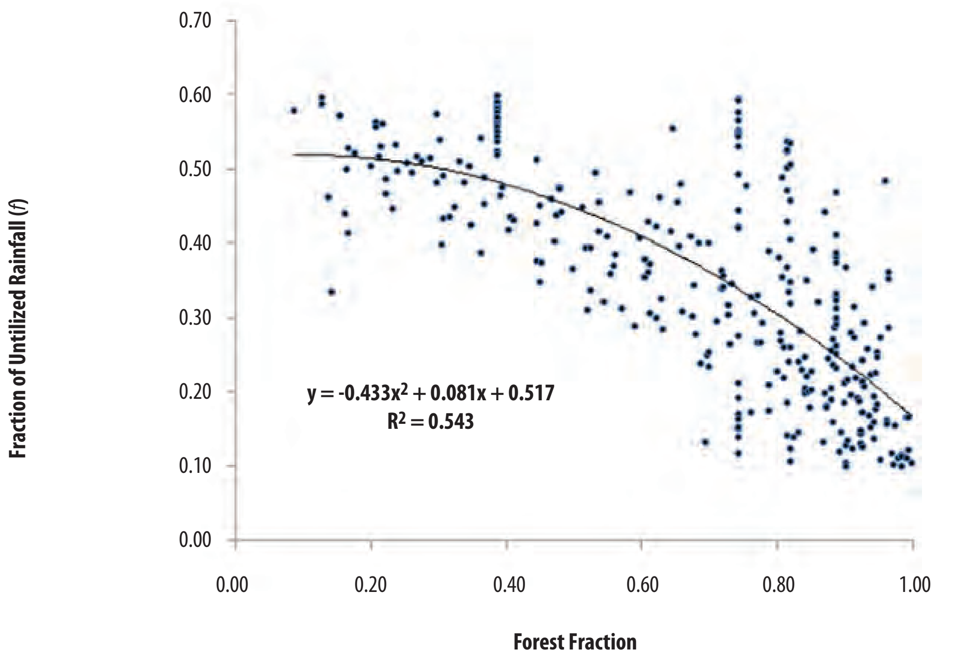


Figure 4.13 Relationship between fraction of unutilized rainfall (f) and forest cover (Heriensyah et al., 2009)

Water demand comes from three sectors: domestic use (urban and rural), industry and agriculture, expressed as follows:

$$Demand = KAFarm + KAPopulation + KAIndustry$$

Water demand for domestic use (KApopulation) was estimated by multiplying population by water consumption per capita (i.e., 120-150 liters/capita/day). For industrial sectors (KAindustry), water demand is estimated based on the size of each industrial area (i.e., 500m3/ha/day). Water demand for industry was estimated based on human development index (HDI), based on assumption that the higher the HDI, the higher the industrial area. The relationship between HDI and industrial areas of a number of districts is shown in Figure 4.14. Water demand for agriculture (KAfarm) was calculated by multiplying agriculture land area bycrop coefficient (kc) and potential evapotranspiration. Because all lands will also evaporate soil water, the rate of soil evaporation or evapotranspiration from all land use cover types was also estimated using a similar formula used for agriculture land.

The projection of future population follows the projection from the Bureau of Statistics (BPS), while agricultural and industrial areas were generated using the following assumptions:

1. Forest cover decreases at rate of 1% per year. Deforestation occurs in all districts. The deforested area in each district is assumed to be equal to the proportion of the forest in the district to the total area of the district.

2. The amount of rice field area in Java was assumed to decrease at a rate of 50,000 ha per year, while outside Java it increases at a rate of 150,000 ha per year.
3. The HDIis assumed to increase in the future. After 2025, districts with HDI equal to less than 65 will increase to 65, those with HDI equal to 65 will increase to 75 and those with HDI equal to more than 75 will increase to 85.

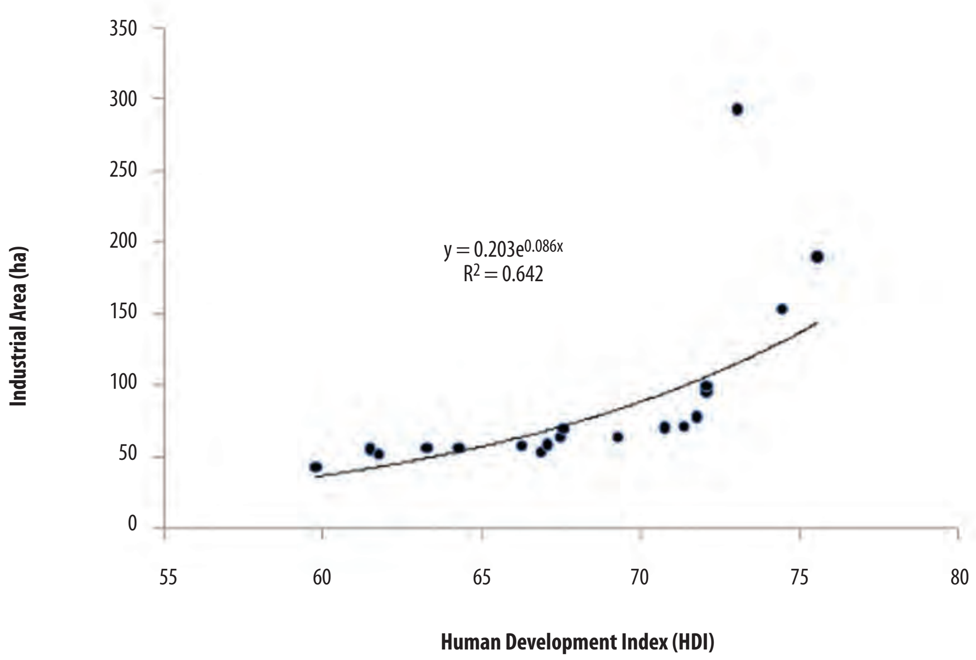


Figure 4.14 Relationship between HDI and industrial areas in Indonesia (Heriensyah et al., 2009)

From the analysis, it was found that the number of months with surplus of water in most of districts in northern parts of Java, Bali, east and west Nusa Tenggara, parts of north Sulawesi, Gorontalo and south Sulawesi, Lampung and south Sumatra are almost zero (Figure 4.15). Some of districts in these provinces are exposed to long periods of water deficit. In some districts, the length of deficits could last up to 12 months, particularly areas in the eastern parts of Indonesia such as east Nusa Tenggara and west Nusa Tenggara. In east Nusa Tenggara, planting even just one crop a year without irrigation is not possible during El Niño years. During El Niño years, the length of the rainy season could be less than 3 months.

Under the future projected climate, the number of districts with no month of water surplus will increase significantly (Figure 4.16). Under the present climate, approximately 14% of the 453 districts across Indonesia have no months with surplus water. Under SRESB1, this is expected to increase to 19% by 2025 and to 31% by 2050, while under SRESA2, it will increase to 21% and 31% by 2025 and 2050, respectively. Table 4.6 shows that most of districts in Bali (more than 70%) do not have any surplus months, followed by NTB, Java (particularly northern parts of Java), Sulawesi (particularly Gorontalo and south Sulawesi) and Sumatra (mostly in southern and eastern parts of Sumatra). With such conditions, increasing cropping index in these islands is not possible, further restricting options for increasing rice production.

The above analysis implies that under changing a climate, more districts will have water scarcity problems (Heriensyah et al., 2009). The development of new initiatives to anticipate the scarcity of water due to climate change and increases on water demand are needed, especially in urban areas where populations are increasing and industrial activities are taking place. Inter-basin transfer of water may be one of the potential options to anticipate the scarcity of water in the future. In Indonesia, many individual basins have surplus water resources even in areas that have reach the ultimate stage of development while others face serious shortages, especially during extreme drought years. Improved storage capacity and inter-basin transfer of water from surplus to deficit regions could therefore be an option for achieving more equitable distribution of water resources and optimal utilization of these resources. The inter-basin technology has been practiced in West Nusa Tenggara.

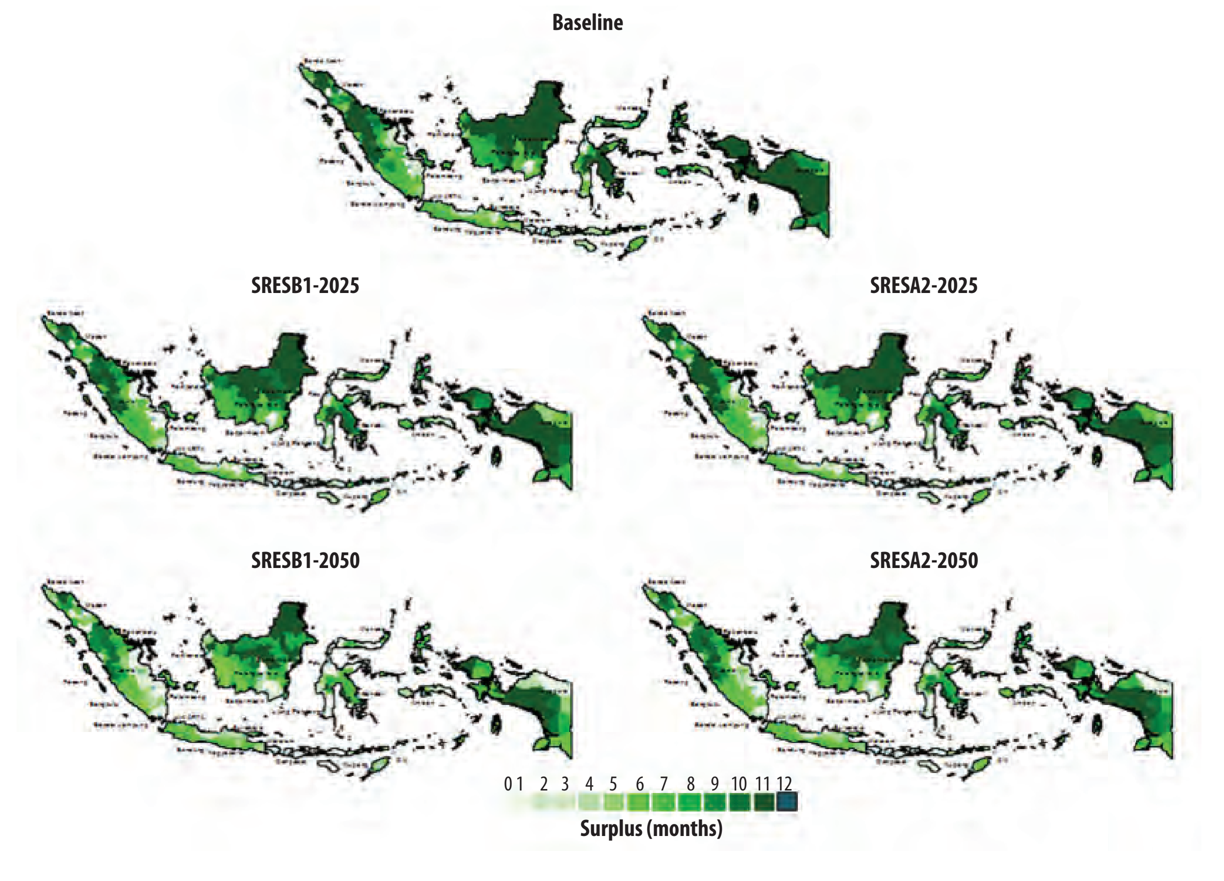
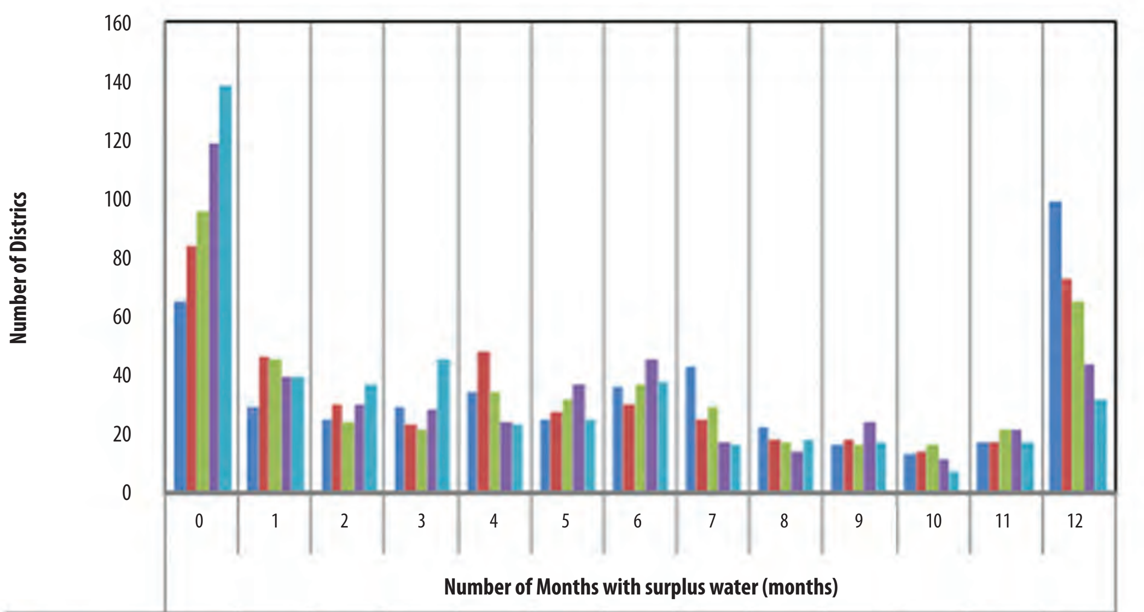


Figure 4.15 Status of water balance under current and future climate (Heriensyah et al., 2009)



	0	1	2	3	4	5	6	7	8	9	10	11	12
Baseline	65	29	25	29	34	25	36	43	22	16	13	17	99
B1-25	84	46	30	23	48	27	30	25	18	18	14	17	73
A2-25	96	45	24	21	34	32	37	29	17	16	16	21	65
B1-50	119	39	30	28	24	37	45	17	14	24	11	21	44
A2-50	139	39	37	45	23	25	38	16	18	17	7	17	32

Figure 4.16 Number of districts without surplus water by length under current and future climate scenarios (Heriensyah et al., 2009). Note: Both the bar graph (top) and table (below) show the same data.

Table 4.6 Number of districts that have no months without water surplus (Heriensyah et al., 2009)

Province	Baseline	B1-2025	B1-2050	A2-2025	A2-2050	Total Number of Distric in the island
Bali	7	8	8	8	9	9
Java	22	26	23	26	23	120
Kalimantan	7	11	12	11	15	54
Maluku	1	1	2	1	2	16
NTB	3	6	8	6	9	10
NTT	1	2	4	2	6	16
Papua	0	0	3	0	3	29
Sulawesi	10	15	30	22	40	63
Sumatera	14	15	29	20	32	135

4.4.3 Forestry

The impact of climate change on tropical forest occurs as a result of changes in soil water availability due to the combined effects of changes in temperature and rainfall. A study in India suggested that projected depletion of soil moisture due to climate change would likely affect teak productivity by reducing the productivity of deciduous forest by approximately 16% (Achanta and Kanetkar, 1996). In Indonesia, however, one important potential threat of climate change on is the increased risk of forest fire due to decreasing dry season rainfall and shortening of the length of the wet season in some part of the region.

During El Niño years 1991/92, 1994/95 and 1997/98,the dry season was extended and carbon emissions from fires measured in 97 monitoring stations across Southeast Asian countries increased significantly (Schimel and Baker 2002). For Indonesia in particular, the strongest El Niño (1997) caused land and forest fire on approximately 11.698 million ha (BAPPENAS-ADB, 1999). Areas most affected by the fire were Kalimantan and Sumatra while the impacts in other provinces were not as severe (Table 4.7). The economic loss caused by the fire was tremendous. OFDA/CRED (2007) stated that these fires were one of the top 10 natural hazards occurred during 1997 and 2007 and the value of all damages and economic losses directly or indirectly related to the 1997/98 fires might reach 17,000 million USD (Table 4.8).

Ardiansyah and Boer (2009) have classified the Indonesian region based on its level of risk to fire. The fire risk was defined based on the monthly pattern of the number of hotspots. Although the hotspot data are not for fire alone, hot spots are closely related to forest and land fire occurrence and smoke fog (e.g., Hooijer et al., 2006). The result of this classification suggested that Indonesia can be classified into 6 cluster patterns (Figure 4.17). Kalimantan and Sumatra were found to be islands that are already exposed to high risk of fire. Based on hotspot density patterns, two provinces shown to have very high hot spot density are Riau Province in Sumatra and Central Kalimantan (Figure 4.17). Hotspot densities in these two islands increases rapidly when dry season rainfall decrease or length of dry season extends, particularly during El Niño years. The hotspot density increased rapidly as the monthly rainfall during the dry season decreased more than 50 mm below normal or when anomaly rainfall was -50 mm (Figure 4.18)

Table 4.7 Area affected by forest fire in 1997/1998 (expressed in ha)

Vegetation	Sumatra	Java	Kalimantan	Sulawesi	Wesst Papua	Total by vegetation type
Montane forest	--	--	213,194	--	100,000	313,194
Lowland forest	383,000	25,000	2,690,880	200,000	300,000	3,598,880
Peat and swamp forest	624,000	--	1,100,000	--	400,000	2,124,000
Dry scrub and grass	263,000	25,000	375,000	--	100,000	763,000
Timber plantation	72,000	--	883,988	--	--	955,988
Estate crops	60,000	--	382,509	1000	3000	446,509
Agriculture	669,000	50,000	2,481,808	199,000	97,000	3,496,808
Total by province	**2,071,000**	**100,000**	**8,127,379**	**400,000**	**1,000,000**	**11,698,379**

Table 4.8 Total national economic loss due to fires during the 1997 El Niño year (expressed in million USD)

Sector	MoE and UNDP (1998)	WWF & EEPSEA (1998)
Agriculture	88.6	130.7
Forestry	508.2	640.6
Health	43.8	256.7
Transmigration	0.2	0.0
Transportation	13.6	4.9
Tourism	4.9	19.6
Fire control	3.2	3.3
Total	**662.4**	**1055.6**

Under both emission scenarios, the seasonal rainfall during SON may decrease over most of the Indonesian region (refer back to Figure 4.10). Most of the 14 GCMs agree that the seasonal rainfall will decrease, particularly in Sumatra and Kalimantan. The decrease in rainfall during this season may result in the delay of the onset of the rainy season, thereby increasing fire risk. Figure 4.19 shows that the risk of fire will increase in the future in certain months and decrease in other months. In general, for Pattern 5 region see (Figure 4.17), the fire risk in October will increase for both scenarios except for SRESB1 in 2050. Similar pattern also found in Pattern 6, the fire risk January will increase for both scenarios except for SRESB1 in 2050.

The Centre for International Forestry Research (CIFOR) also found that future risk of fires in parts of Kalimantan, Sumatra and west Java would be greater than in the past due to an increase in average drought indices and the number of days with 'extreme' danger rating (Figure 4.20).

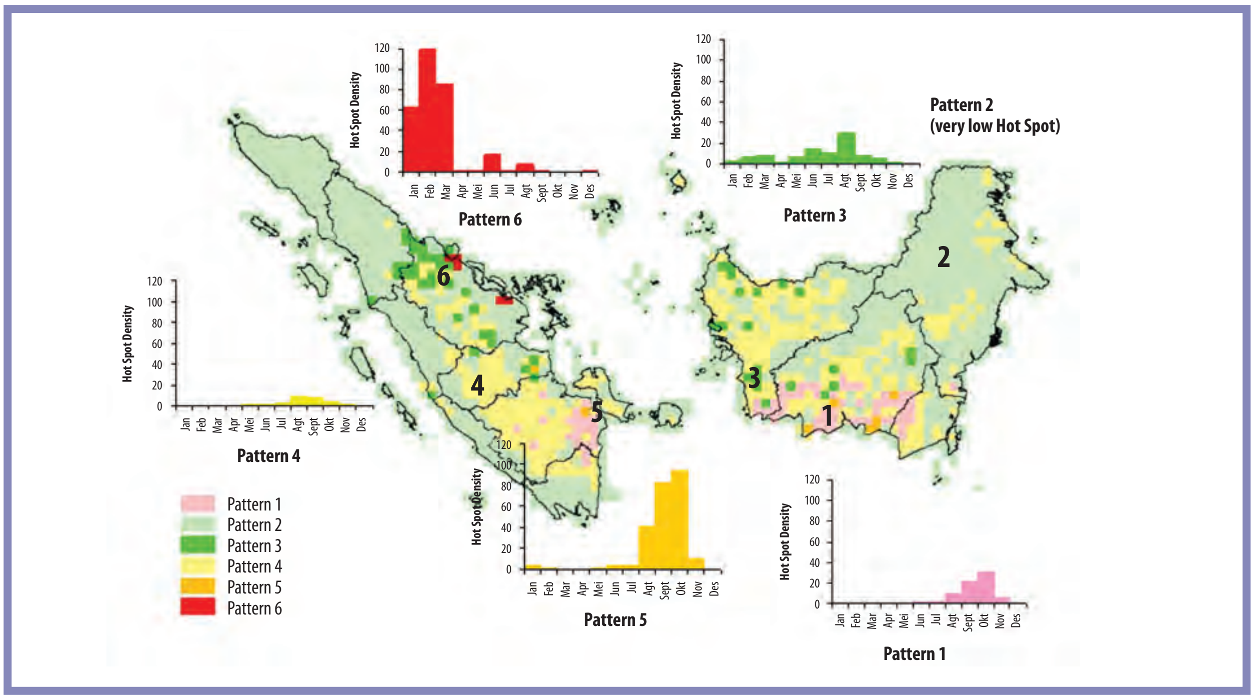


Figure 4.17 Classification of regions at risk to fire based hotspot density patterns – Sumatra (left) and Kalimantan (right) (Ardiansyah and Boer, 2009

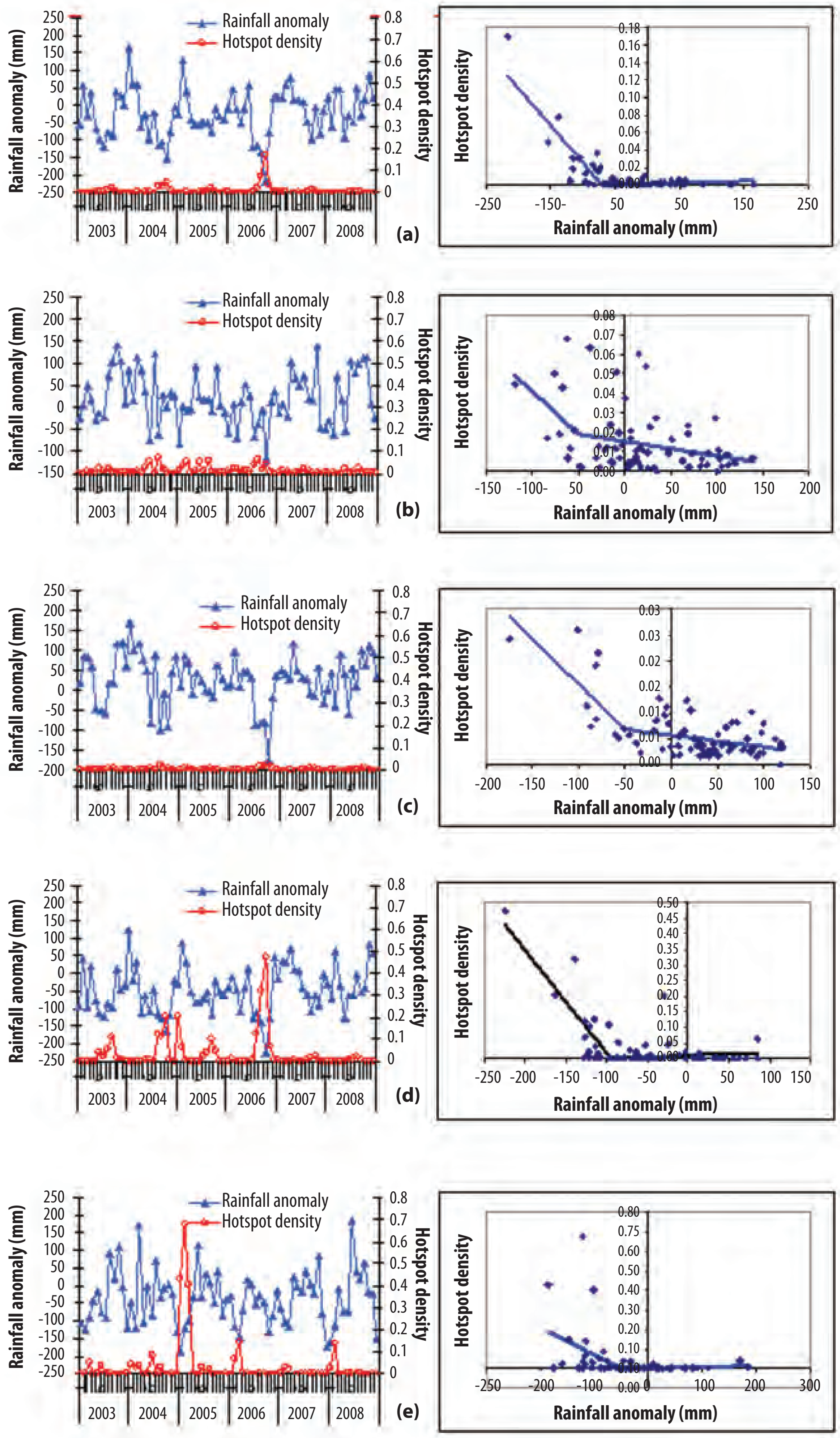


Figure 4.18 The relationship between hotspot density and rainfall anomaly in Kalimantan and Sumatra for (a) Pattern 1, (b) Pattern 3, (c) Pattern 4, (d) Pattern 5 and (e) Pattern 6

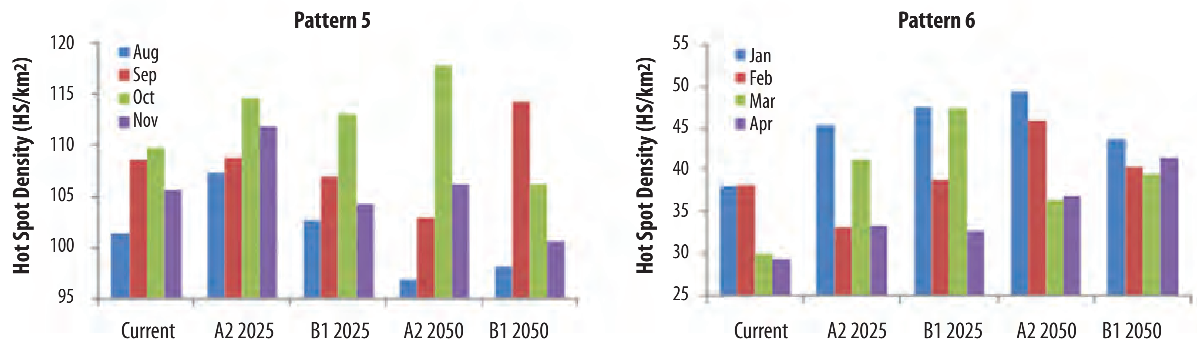


Figure 4.19 Median value of hot spot density for pattern 5 and pattern 6 regions under current and future climate (Ardiansyah and Boer, 2009)

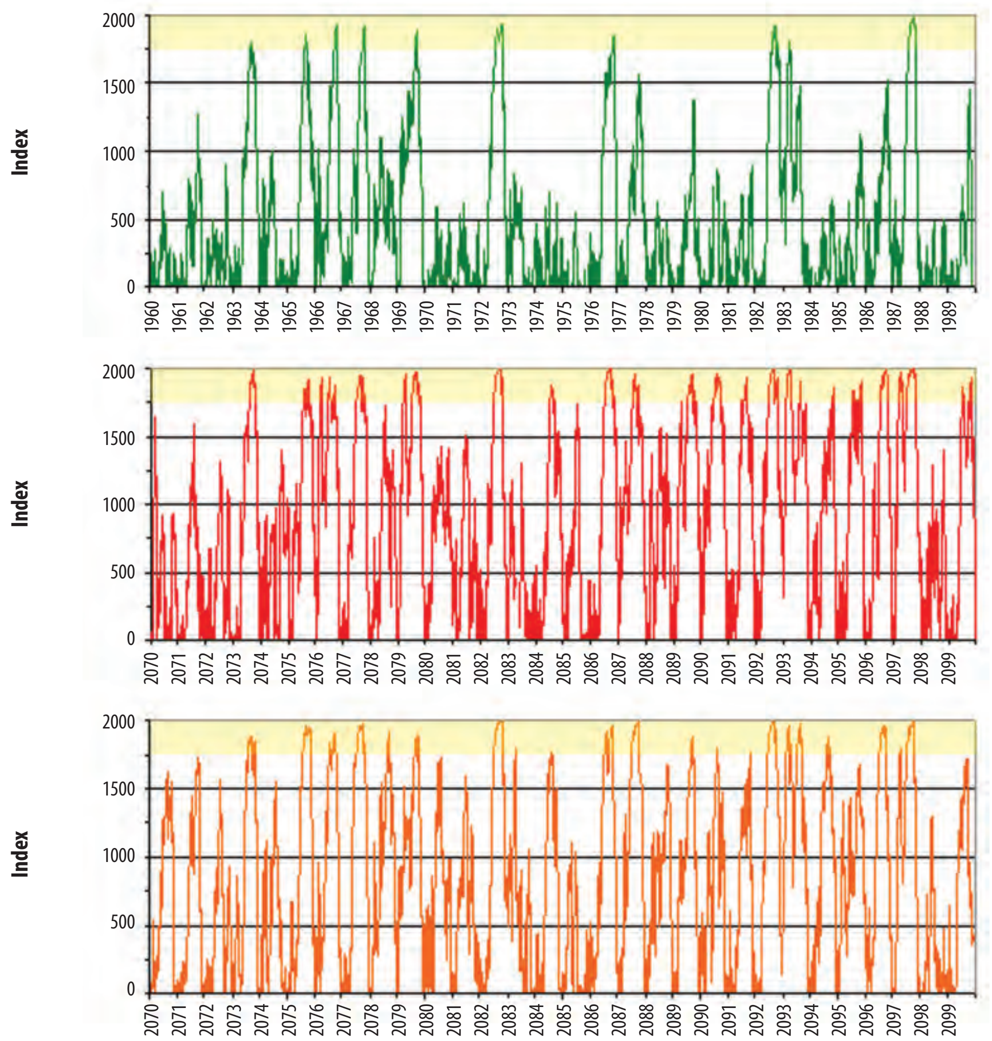


Figure 4.20 Keetch and Byram Drought Index for baseline period of 1960-1990 (top), for A2 projection period of 2070-2100 (middle) and for B2 projection period of 2070-2100 (bottom) foreast Kalimantan, Indonesia. The fire danger index rating classes are: low (0-999); moderate (1000-1449); high (1500-1749); extreme (1750 -2000). Source: CIFOR (2008)

Based on the above finding, the risk of repeated fires may increase under a changing climate. Under such conditions, the threat to biodiversity loss will increase. A study in East Kalimantan showed that the number of trees that survived in plots that experienced fire in 1982/83 and again in 1997/98 decrease significantly (Figure 4.21; Ngakan, 2002). Furthermore, even eleven years after fires, the number of species in plots that were lightly, moderately and severely damaged was not significantly different. However, the species composition was still noticeably different. The trees in lightly-damaged plots were dominated by primary (climax) species (Figure 4.22) such as Aglaia cinere, Madhuca malacensis, Mallotus mpritsianus, Eusideroxylon zwageri, etc.

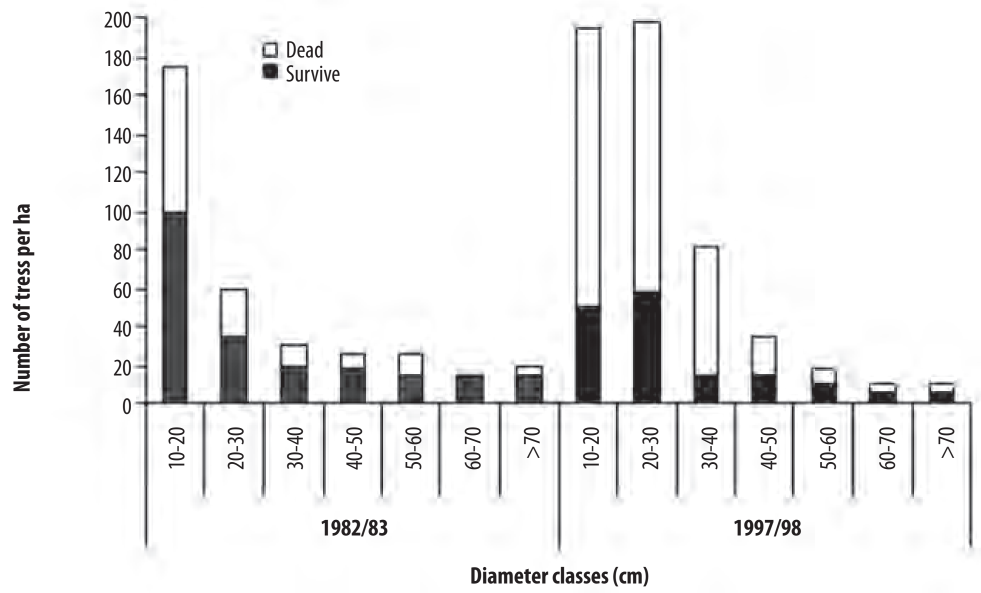


Figure 4.21 The number of surviving and dead trees per hectare after forest firesin 1982/83 and 1997/98 (Ngakan, 2002)

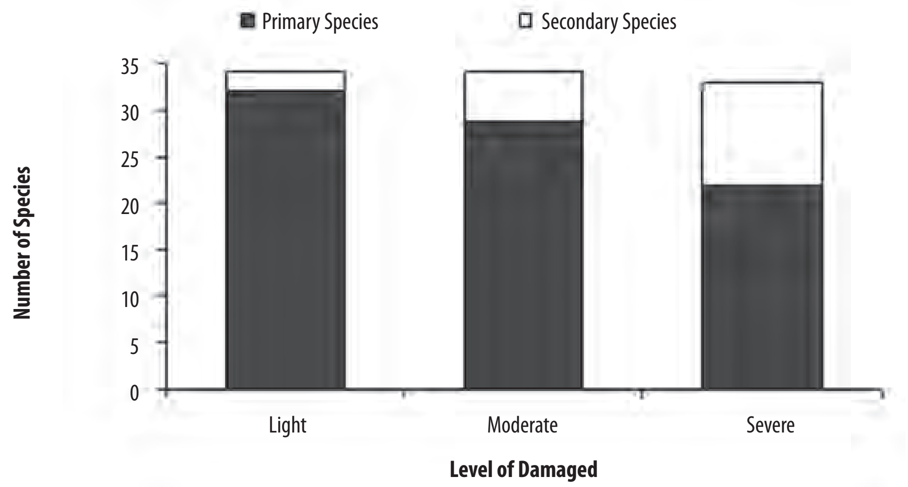


Figure 4.22 Composition of species per hectare in plots which were lightly, moderately and severely damaged by fires in Kutai National Park, East Kalimantan

Other impacts of climate change on forest ecosystems may also include the disappearance or reduction of density of certain species due shifts in ideal temperature and rainfall range, increasing forest disease and pest infestation, the increase or the decrease of forest productivity, etc.

As defined in Chapter 5, the Government of Indonesia has issued a number of policies and regulations to reduce risk of land/forest fire. There are at least 7 legal instruments designed to control fire. These legal instruments are in the form of Acts, Government Regulations, Minister Decrees from the Ministry of Forestry, Ministry of Environment and Ministry of Agriculture, Director General Decrees, etc. A number of programs have been implemented for fire management through the establishment of community-based fire management systems, early warning systems, etc.

4.4.4 Coastal and Marine

The impacts of climate change on coastal areas can be divided into two categories: biophysical and socio-economic impacts. Biophysical impacts include (IPCC, 2005): (i) increased coastal erosion, (ii) inhibition of primary production processes, (iii) increased flood frequency, (iv) increased intensity of flood events caused by storm-surge, (v) saltwater intrusion into estuaries and aquifers, (vi) changes in the quality of surface water and groundwater characteristics, (vii) changes in the distribution of pathogenic micro organisms and (viii) increasing sea surface temperatures. Economic and social impacts include (i) increasing number of homes lost and coastal habitats, (ii) increased risk of flooding and the number of lives potentially lost, (iii) damage to buildings and other infrastructure, and coastal protection, (iv) increased risk of disease outbreaks, (v) loss of resources that can be replaced (vi) loss of tourism, recreation and transportation, (vii) loss of cultural assets and historical values and (viii) impacts on inland fisheries and agriculture due to declining quality of soil and water as a result of saltwater intrusion.

In Indonesia, the potential impact of climate change on coastal areas and fisheries is significant. From historical data, it is clear that the increase in sea temperatures during El Niño years has caused serious coral bleaching. Coral bleaching occurred in Indonesian waters in 1983, including the Sunda Strait, and the Thousand Islands, and Karimun Java Sea. This resulted in high numbers of dead coral. In 1998, widespread coral bleaching occurred again, but indifferent locations, this time in East Sumatra, Java, Bali and Lombok. In the Thousand Islands, 90-95% of coral at depths up to 25 m suffered bleaching and death (World Resources Institute [WRI], 2002). Meanwhile, Bali experienced 75-100% coral bleaching. According to the World Wildlife Fund (WWF), the 1998coral bleaching event was triggered by El Niño. The 1982/83 and 1997/1998 El Niño events have been defined as the two strongest El Niño events during the last century. The Indonesian Coral Reef Foundation (TERANGI) (2007) also reported coral bleaching in the Thousand Islands in February 2006 and February 2007, even though the El Niño during this period was not as strong as those that occurred in 1982/83 and 1997/98.

Coral bleaching has significant impacts on fish populations as it is the habitat of thousands of species of reef fish. In addition, the reef also functions as a high energy and wave absorber that reduces the risk of coastal erosion. Therefore, damage to reefs increases the risk of coastal erosion. The increasing frequency of storms resulting in high waves can also cause clusters of coral damage. Due to its world renowned biodiversity and aesthetic beauty, beaches in Indonesia have become a popular tourist destination and is a significant source of revenue for Indonesia. In general, the number of tourists who visit Indonesia tends to increase and provide major revenue for the government (Ministry of Culture and Tourism, 2010). However, if not managed appropriately, tourism activities can also cause damage to coastal areas, including coral reefs, and beaches.

Rising ocean temperatures will also inhibit the growth of phytoplankton, which many important species of fish depend on. Fish area resource that can move from one place to another, across borders between countries. For example, the migration of Pacific salmon from USA to Canada is suspected to be attributed to a rise in Pacific Ocean temperatures. This situation pushed the two countries to establish a single agreement on salmon fishing (Miller, 2000). The increase in ocean temperatures will also change the pattern of currents, wind and rain patterns. Warmer ocean water can prevent the proliferation of plankton thereby reducing the availability of fish food. Some fish species such as pelagic will likely migrate to other regions that offer suitable temperature conditions and food availability. This will adversely affect the attainment of development objectives in the fisheries sector.

Coastal erosion has also been observed in many parts of Indonesian coastal areas due primarily to sea level rise (SLR) and strong wave action. Based on data released by the Ministry of Public Works, about 40% of the 81,000 km coastline has been eroded. Along the northern coast of Java, the coastal erosion impacts on 5,500 hectares of land are spread over 10 districts. For example, in Tegal Regency, erosion of 40 km of shoreline has resulted in moving the coast line inland as far as 50 to 100 meters. Approximately 3 km out of the 10.5 km of shoreline erosion has also resulted in a loss of 25 ha of ponds.

The increase in wind speed, sea level, and wave and tidal action due to climate change will have significant impacts on coastal and marine resources. As an island country, Indonesia will suffer significantly from climate change-induced sea level rise. The following sections describe briefly the impact of sea level rise on four coastal cities of Indonesia, Jakarta, Medan, Semarang and Surabaya using three scenarios. The first scenario assesses the impact of sea level rise that may cause the permanent inundation of some of the coastal areas. The second scenario assesses the impact of sea level rise combined with high tides. The third scenario assesses the impact of sea level rise combined with land subsidence. The economic losses due sea level rise were assessed based on the area and type of land use affected by the sea level rise. The four main land use types affected by sea level rise in the coastal cities include settlement, rice fields, ponds and harbors/airports. The value of economic losses due to the inundation of the respective land use types were collected based on literature studies (Table 4.9).

Table 4.9 Economic loss per ha of affected land use type

Land Use/Land Cover	Damages in rupiahs (IDR)			Source
	Low	Medium	High	
Harbors/airports	-	37,500,000,000	-	1
Ponds (prawn/fish)	2,150,000	2,200,000	2,250,000	3
Settlements	1,640,000	2,695,000	3,750,000	2
Wet rice fields	1,750,000	3,000,000	5,500,000	4

Source: 1Batam Pos, 2BPSDA (2003), 3 Kartikasari and Boer et al (2007) and4 Sasmita (2006)

MEDAN CITY

This case study covers the area of Medan and part of the Deli Serdang Regency. Medan topography is undulating with an altitude between 2.5 and 37.5 meters above sea level (a.s.l.); Deli Serdang area topography is similar to the Medan municipality. Due to the topography, this region is not vulnerable to flooding due to sea level rise equal to one meter or less. The probability of coastal areas affected by flooding due to sea level rise alone (Scenario 1) is low even with sea level rise up to 1 m. However, when combined with high tide (2.69 m), a significant area will be inundated. The time scale of this flood is not permanent and only temporary. Based on this scenario, the most extensive areas affected are Harapan Perak in Deli Serdang District and Medan Labuhan in Medan Municipality (Figure 4.23).The extent of water flooding inland due to sea level rise and high tide is varied depending on the topographic of the area. The maximum height of flooding and the total area temporarily inundated is shown in Figure 4.24. Because of the nature of the floods in this region are only temporary, the damage to infrastructure is small, but if the flood affected the functions of wetlands and ponds, damage will be high and lead to large economic losses.

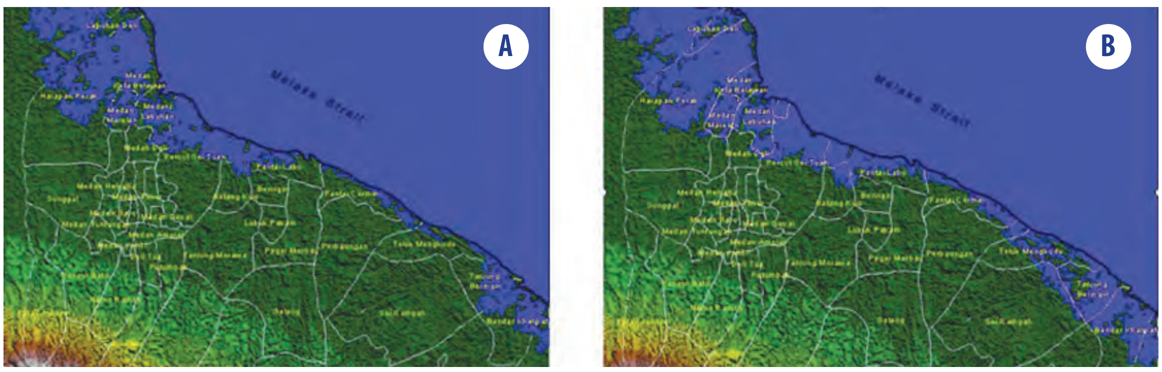


Figure 4.23 Distribution of floods based on the scenario of sea level rise + high tide: 0.25+2.69 m (A) and 1.0+2.69 m (B). Source: Hariati et al.,2009

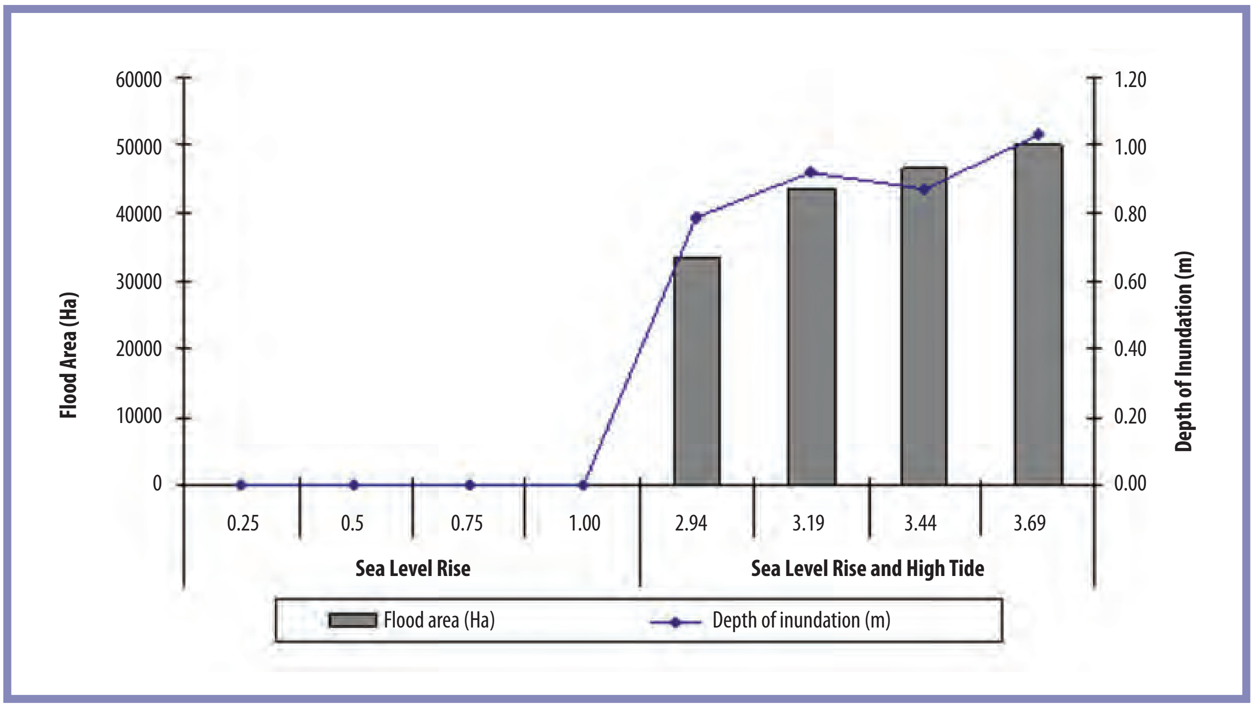


Figure 4.24 Distribution breadth and depth of inundation due to sea level rise and high tide of Medan and surrounding areas (Hariati et al., 2009)

The main land use types situated below an elevation of 100 m a.s.l. are ponds, dry land farming and settlements. Distribution of settlement is more concentrated in Medan than in Deli Serdang. The size of settlements likely to be affected by flooding are 320-770 ha, and this will threaten the residents who live in the area. With sea level rise of 2.94 meters (0.25+2.69 m), the total population affected by the temporary flood is approximately 370,000 people; when sea level rise increases by 3.69 meters, the population affected increases to 1 million people. The damage on settlements may not be significant, so the loss is assumed to be zero. However, the impact on rice fields and ponds will be high as it will damage the crop due to saltwater intrusion and flush out the fish in the ponds. With sea level rise of 2.94 meters, the total area of wetland ponds affected by flooding is almost 18,000ha, equivalent to an economic loss of approximately47 billion IDR. With sea level rise of3.69 meters, the amount of economic loss increases to approximately 69 billion IDR (Table 4.10).

Table 4.10 Impact of sea level rise and high tide on population and land use in Medan (Hariati et al., 2009)

Scenario		Population (x 1000)	Economic Loss (billion IDR)				
			Settlement	Rice	Ponds	Harbor/Airport	Total
SLR + Tides + Waves (m)	2.94	368	0.00	29.24	17.50	0.00	46.74
	3.19	588	0.00	40.41	21.06	0.00	61.48
	3.44	761	0.00	43.23	21.95	0.00	65.19
	3.69	998	0.00	46.02	22.73	0.00	68.75

JAKARTA CITY

Some areas of Jakarta are located at low elevation or even below sea level (Satkorlak PBP Jakarta 2006). Based on SRTM data analysis, the low elevation areas are distributed across four municipalities (Table 4.11). The size of the areas with an elevation below sea level rise ranges from 90 to 2020 ha. The largest area is situated in North Jakarta and the smallest area is in Central Jakarta. In North Jakarta, low elevation areas are distributed among the six sub-districts of Cilincing, Kelapa Gading, Koja, Pademangan, Penjaringan and Tanjung Priok, while the specific villages with the lowest elevation are Sunter Agung, Papango, and Tanjung Priok (Figure 4.25).

Table 4.11 Percent distribution area of low elevation (≤0 meters below sea level in DKI Jakarta

No.	Municipality	Are	
		(ha)	(%)
1.	West Jakarta	244.5	9.9
2.	Central Jakarta	91.4	3.7
3.	East Jakarta	105.1	4.3
4.	North Jakarta	2020.7	82.1
Total		2461.7	100.0

Source: Analysis of SRTM data

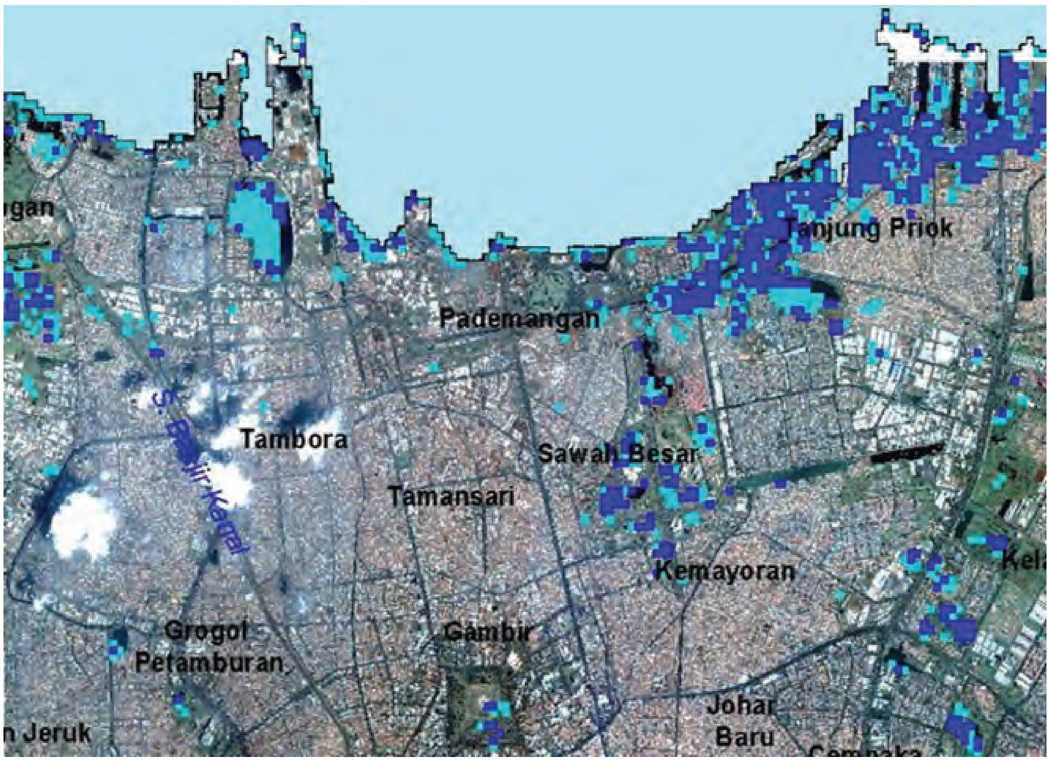


Figure 4.25 Distribution of low elevation (≤ 0 meterdpal) areas in DKI Jakarta

Under Scenario 1, some of the Jakarta area will be permanently inundated due to a sea level rise of 0.25 m. The most affected areais located in the Sunter Agung and Papango of Tanjung Priok sub-districts. The flood depth may reach 11 cm and in some locations can increase up to 20 cm. The coastline will move inland by approximately 1.5 km from its current location. If sea level rises up to 1 m, the area that will be permanently inundated will increase significantly and more sub-districtswill be affected, including Tanjung Priok and Koja (North Jakarta) and Penjaringan and Kalideres (West Jakarta) with a mean flood depth of approximately 30 cm. The coastline will move inland by approximately 2.0 km from its current location (Figure 4.26). Combined with high tide (Scenario 2), the total area that will be inundated will be much larger. The depth of flood and total flooded area under Scenarios 1 and 2 are shown in Figure 4.27.

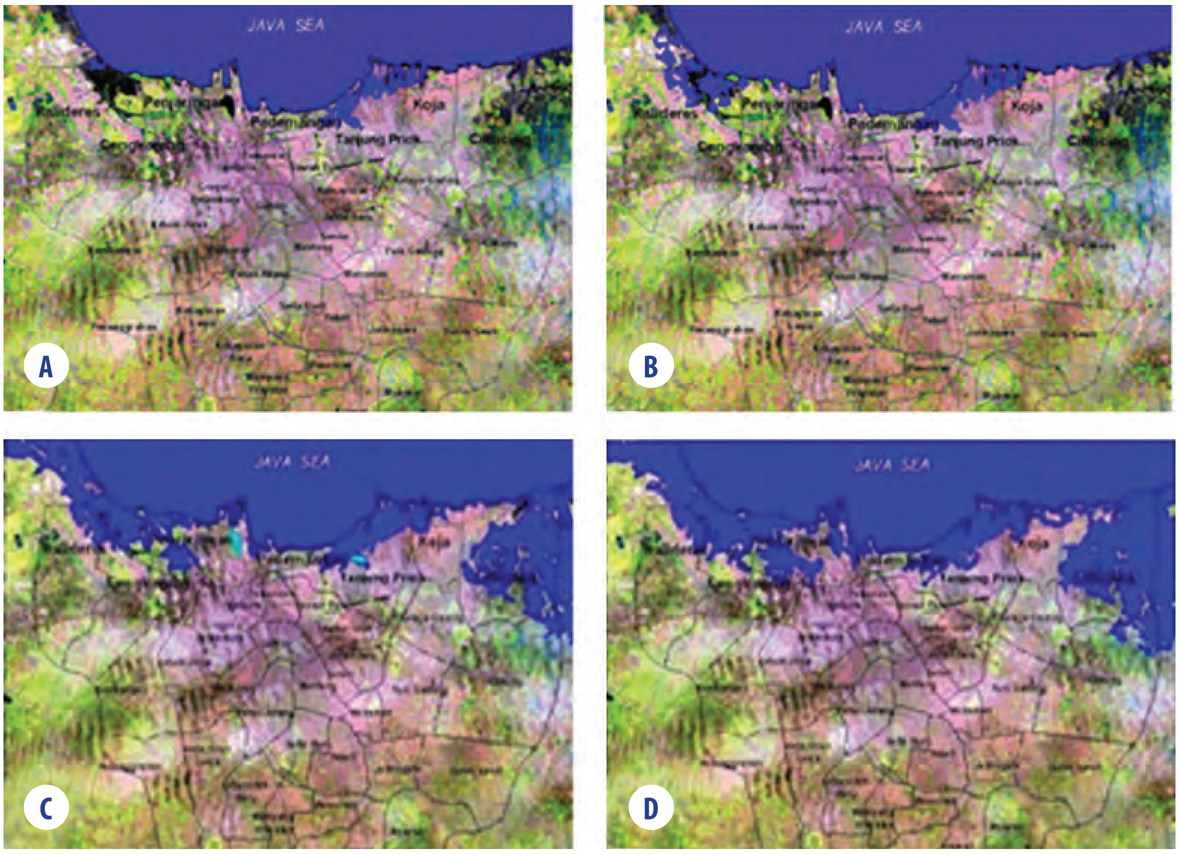


Figure 4.26 Distribution of floods based on sea level rise of 0.25 m (A), 1.0 m (B), sea level rise + high tide of 2.28 m (C) and sea level rise + high tide of 3.03 m (D). Source: Hariati et al., 2009

Based on the overlay of population density maps and flood area, the size of the population affected by a sea level rise of 0.25 and 1.0 m will be approximately 74,000 and 130,000, respectively (Figure 4.28). If the level of sea level rise is combined with high tide, the total number of people affected will increase to 236,000and 381,000 people, for 2.28 m and 3.03 m, respectively (Figure 4.28).

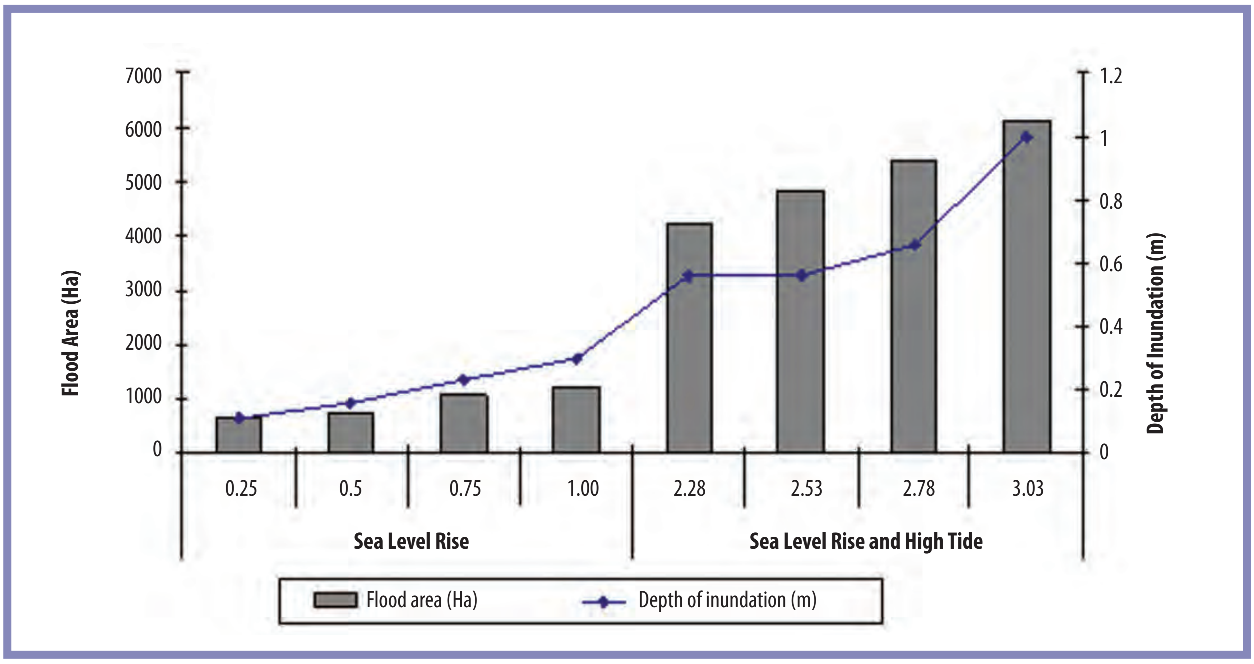


Figure 4.27 Area of flooding and depth of flood due to sea level rise and high tide in the Jakarta region. Source: Hariati *et al.*, 2009

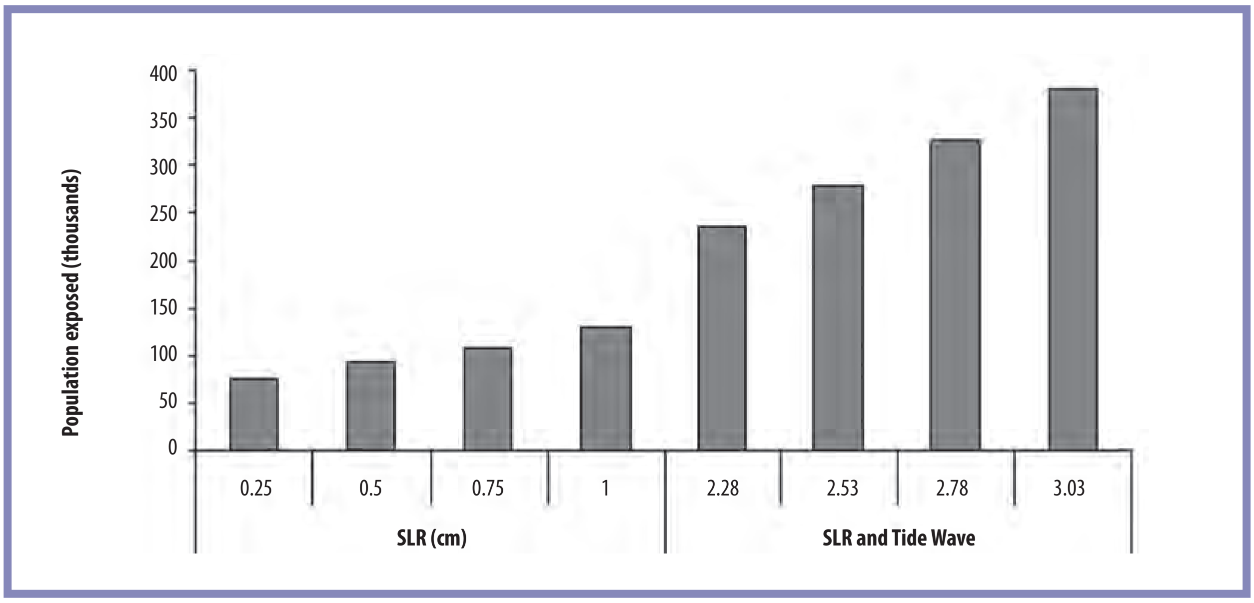


Figure 4.28 Number of residents affected by flooding due to sea level rise and high tide in Jakarta. Source: Hariati *et al.*, 2009

The impact of sea level rise on the city of Jakarta was assessed based on four land use types: residential, wetland, ponds and ports. With sea level rise of less than 0.25 m, the economic loss will reach approximately 6,500 billion IDR; if sea level rise increased to 1.0 m, the loss will increase to more than 8,600 billion IDR (Scenario 1). If the impact of sea level rise is combined with high tide (Scenario 2), the loss will not be much different from that of Scenario 1 (Table 4.12). This is due to the nature of floods in the second scenario, which are only temporary. It is assumed that the damage caused by the temporary flood in settlements and airport is not significant. The impact of temporary flooding is only significant on rice field and ponds. In this analysis, the economic impact of temporary floods through their effect on flight landing and take-off at airports is not taken into account.

Table 4.12 Impact of sea level rise and high tide on the population and land use in Jakarta. Source: Hariati *et al*., 2009

Scenario		Number of people affect ed (in thousands)	Economic Loss (billion IDR)				
			Settlements	Rice	Ponds	Harbor/ Airport	Total
SLR (m)	0.25	74	1.00	0.06	0.12	6,489.56	6490.74
	0.50	93	1.27	0.07	0.23	7,202.44	7204.01
	0.75	109	1.63	0.08	0.62	7,881.83	7884.16
	1.00	130	2.15	0.28	0.71	8,622.76	8625.90
SLR + tides and wave action (m)	2.28	236	1.00	8.49	1.48	6,489.56	6500.53
	2.53	280	1.27	9.50	1.55	7,202.44	7214.76
	2.78	325	1.63	10.15	1.63	7,881.83	7895.24
	3.03	381	2.15	11.05	1.71	8,622.76	8637.67

It should be noted that land subsidence problems already exist in Jakarta. However, due to unavailability of spatial data on land subsidence, analysis for Scenario 3 was not conducted. Based on a number of reports (Abidin *et al*., 2009; Djaya *et al*., 2004), subsidence in several places in the metropolitan area of Jakarta ranging from 20 to 200 cm occurred over the period from 1982-1997. In general, land subsidence exhibits spatial and temporal variations, with the rates of about 1-15 cm/year, but in a few locations, the subsidence rates reached 20-25 cm/year (Abidin *et al*., 2009). The four main factors causing land subsidence in Jakarta are ground water extraction, load of constructions (i.e., settlement on high compressibility soil), natural consolidation of alluvial soil and tectonic subsidence (Abidin *et al*., 2009). Overall, land subsidence may have more serious impacts than that of the global warming on land inundation on the City of Jakarta.

SEMARANG CITY

The impact of sea level rise on Semarang City will be severe, as the city already experiences problems with land subsidence (Georisk Project, 2008). In Semarang, the primary factor that triggers land subsidence is the increased consumption of ground water. As a result, hydraulic pressure in the soil layer declines (referred to as cone depression of groundwater), followed by the decrease of the soil surface. This condition will be more severe when the area above ground incurs additional burden, such as settlement building. Based on the Georisk Project report (2008), the cone depression in the area of Semarang widened east wards from 1984 to 2000. Based on these observations, it is assumed that the direction of growing land subsidence is toward the east (Figure 4.29A).The rate of land subsidence ranged from 0-1 cm/year up to 8-9 cm/year (Figure 4.29B). The highest rate of land subsidence (8-9 cm/year) occurred in most of North Semarang and Genuk; the lowest rate of land subsidence (0-1 cm/tahun) occurred in Tugu, Central of Western Semarang, and southernpart of Central Semarang, East Semarang, Gayamsariand Padurungan.This data wasused as the basis for projecting land subsidence up to 2100.

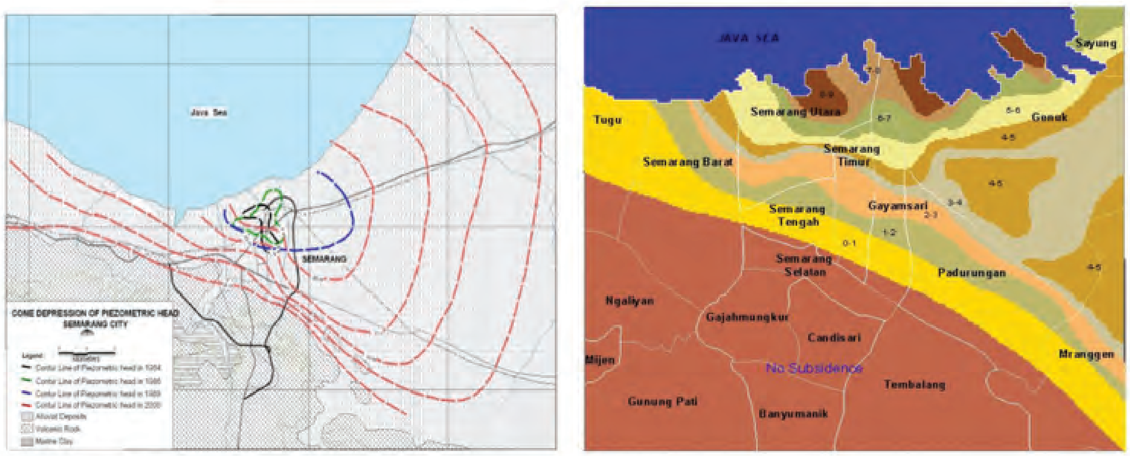


Figure 4.29 (A) Growth of cone impairment (cone depression) in the groundwater aquifer from 1984 until 2000, and (B) land subsidence rates in Semarang City. Source: Georisk Project, 2008

Under Scenario 1, it was found that total area in Semarang City that will be permanently inundated by sea level rise of 0.25 m is less than 600 ha with a flood depth of approximately less than 20 cm. The sub-district with the greatest area affected by flood is Genuk, while the sub-district with the smallest area affected is Tugu. With sea level rise up to 0.50 and 1.0 m, the coastline is projected to move inland between approximately 700-1000 m, and 1000-1300 m, respectively. In the three most affected sub-districts of Semarang (Tugu, Semarang Utara and Genuk), the coastline will move inland by approximately 680, 860 and 1000 m respectively, with a sea level rise of 0.5 m, (Figure 4.30A); with sea level rise of 1.0 m, the coastline will move inland by 1300, 1000 and 300 m, respectively (Figure 4.30B). Under Scenario 2, combining sea level rise with a tidal height of 2.03 m, more land will be inundated, but it will be only temporarily (Figures 4.30C and 4.30D). The total area flooded and the depth of the flood under Scenarios 1 and 2 are presented in Figure 4.31.

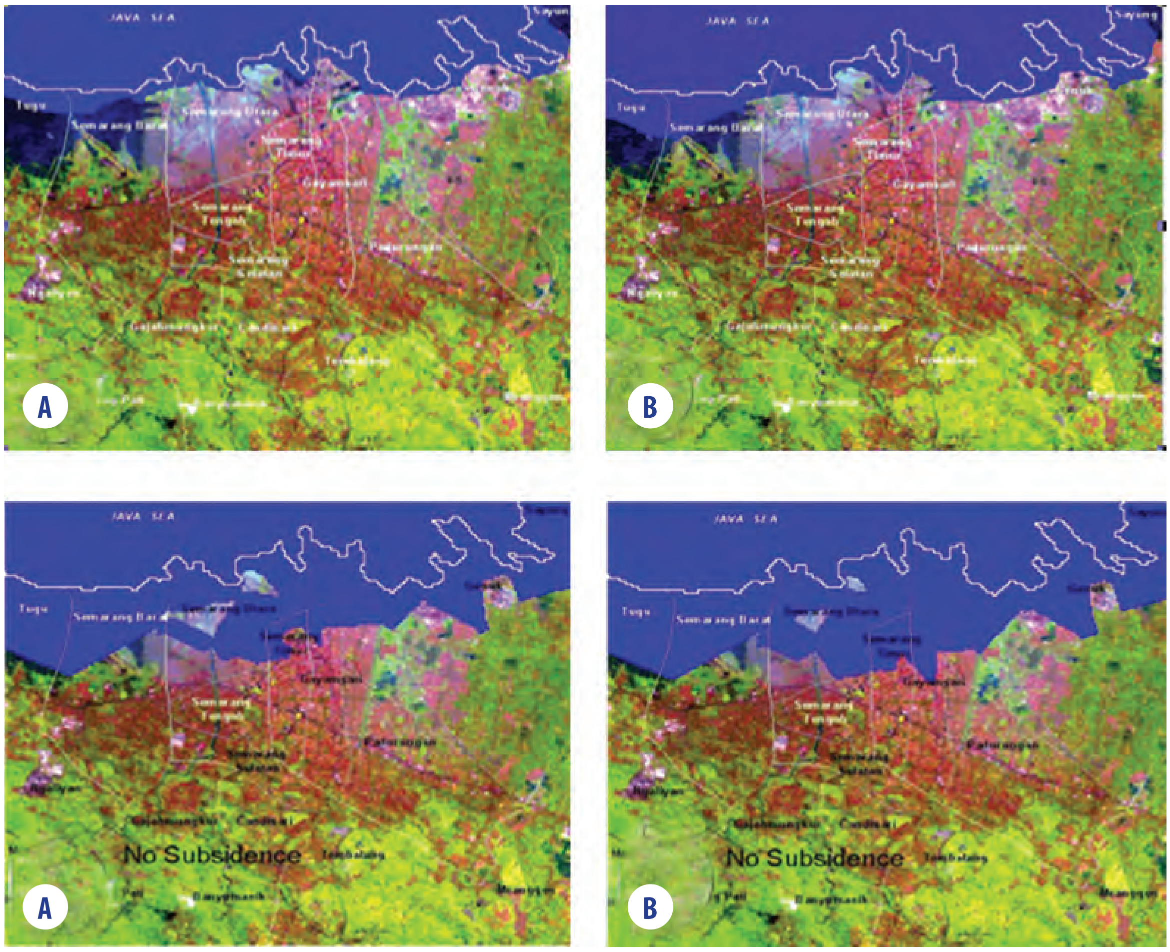


Figure 4.30 Distribution of floods based a sea level rise of 0.25 m (A), 1.0 m (B), and sea level rise + high tide equal to 2.28 m (C) and 3.03 m (D) in Semarang. Source: Hariati et al., 2009

Under Scenario 3 (sea level rise combined with land subsidence), the areas permanently inundated are similar to those of Scenario 2 (Figure 4.32). With sea level rise of 1.0 m combined with land subsidence, the total area inundated may reach approximately 4,000 ha with a flood depth of about 1.6 m (Figure 4.33). Based on this condition, the plan to re-locate people who live in the coastal areas of Semarang, particularly in Tugu, Semarang Utara and Genuk sub-districts should be designed as soon as possible. At present, in order to adapt to sea level rise and land subsidence, the community has to raise their floors every 5 years by about 50 cm to avoid flooding in their houses during high tide. Table 4.13 shows the projected shoreline retreat in the three sub-districts due to sea level rise and land subsidence.

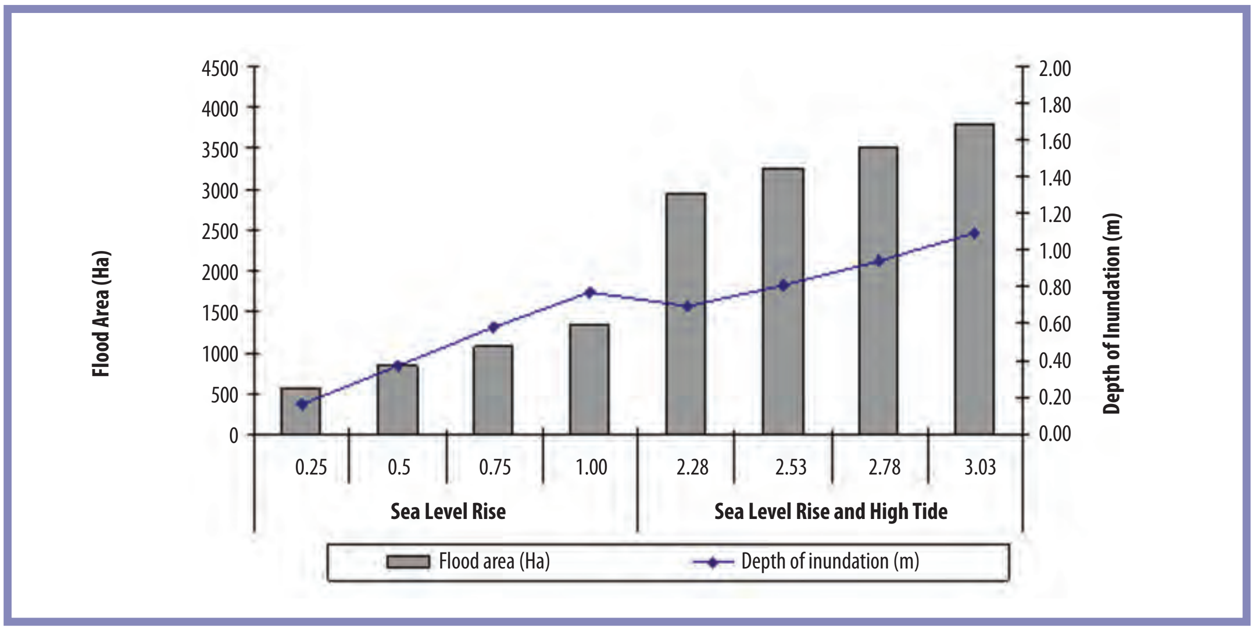


Figure 4.31 Flood area and flood depth due to sea level rise and high tide in Semarang. Source: Hariati et al., 2009

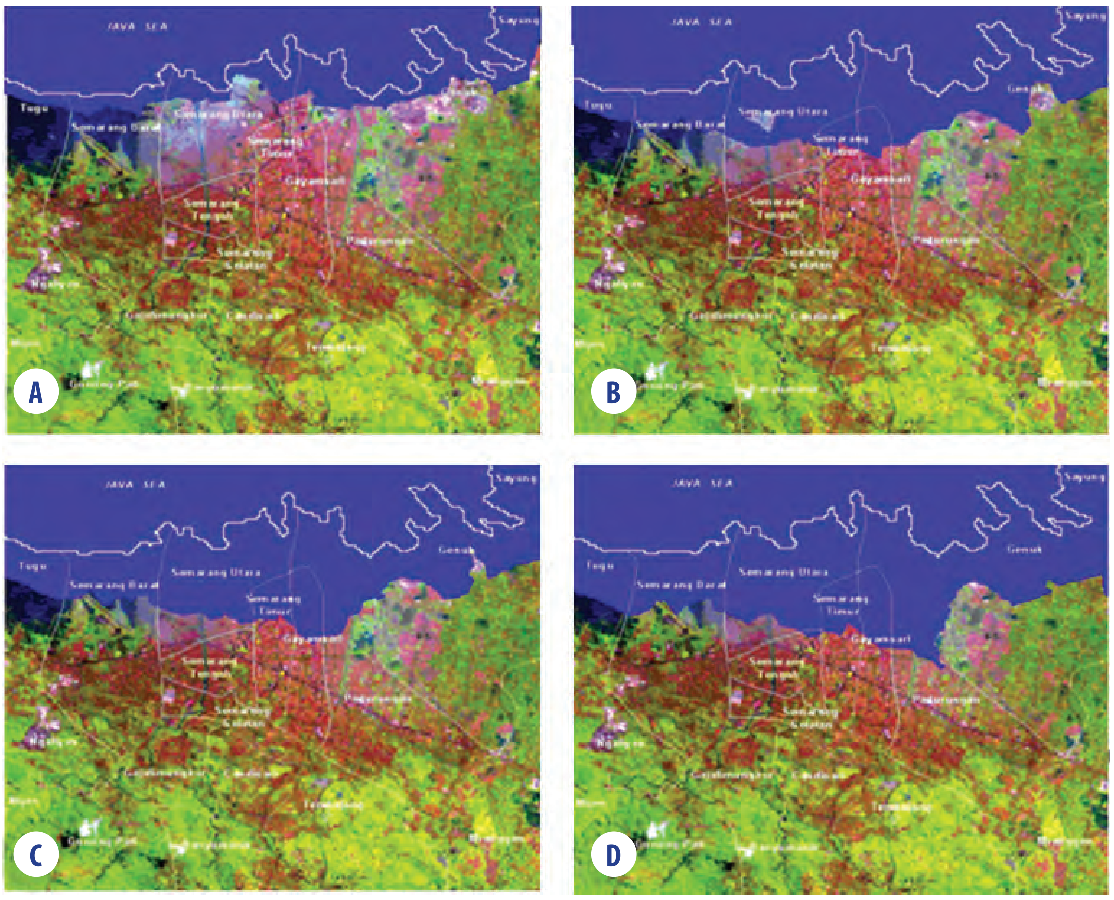


Figure 4.32 Distribution of floods based on land subsidence and sea level rise of 0.25 m (A), 0.50 m (B), 0.75 m (C) and 1.0 m (D). Source: Hariarti *et al*., 2009

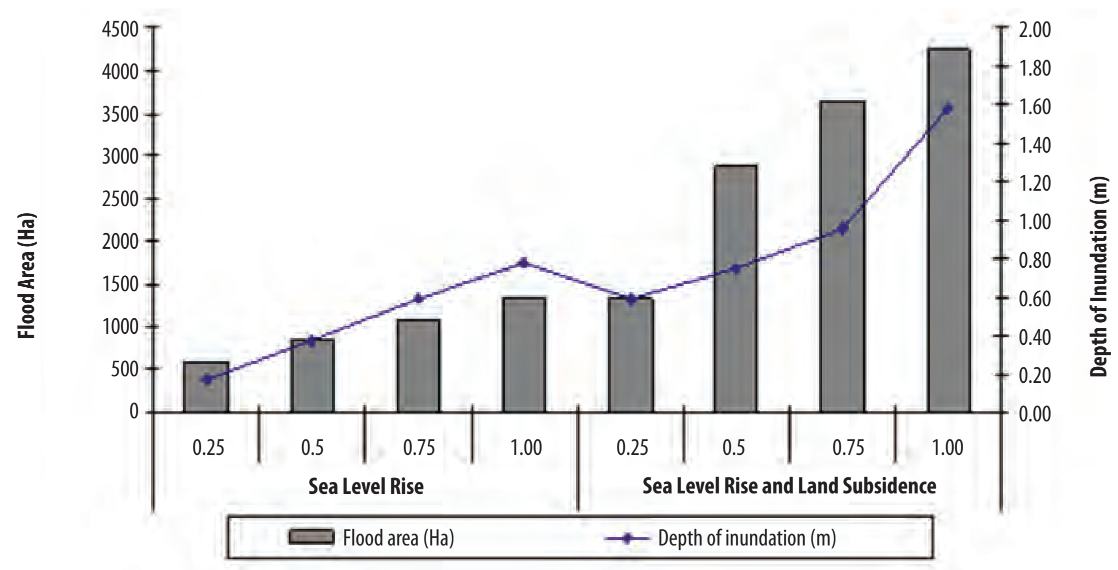


Figure 4.33 Flood area and flood depth due to sea level rise and land subsidence in Semarang area. Source: Hariarti *et al.*, 2009

Table 4.13 Shoreline retreat due to sea level rise and land subsidence (Hariarti et al., 2009)

No.	Sub-District	Coast line movement in land due to sea level rise (m)		Coast line movement in land due land subsidence (m)	
		0.5 m	1.0 m	0.5 m + land subsidence	1.0 m + land subsidence
1	Tugu	700	1300	930	1800
2	North Semarang	800	1030	2300	2800
3	Genuk	950	1200	2970	4300

Sea level rise of 0.25 and 1.0 will threaten approximately 31,000 and 114,000 people, respectively. If sea level rise occurs simultaneously with high tide, the number of people threatened by floods increases. With a total increase in sea level of 2.28 and 3.03 m as a result of high tide and sea level rise, the number of people threatened increases to approximately between 177,000 and 443,000, respectively (Figure 4.34).

The economic loss due to sea level rise ranges considerably depending on whether the area is inundated temporarily or permanently (Table 4.14). Under Scenario 1, sea level rise of 0.25 m will result in an economic loss of approximately 1.5 billion USD, while if the sea level rises1 m and is combined with land subsidence, the total economic loss may reach 378 billion USD (Table 4.14).

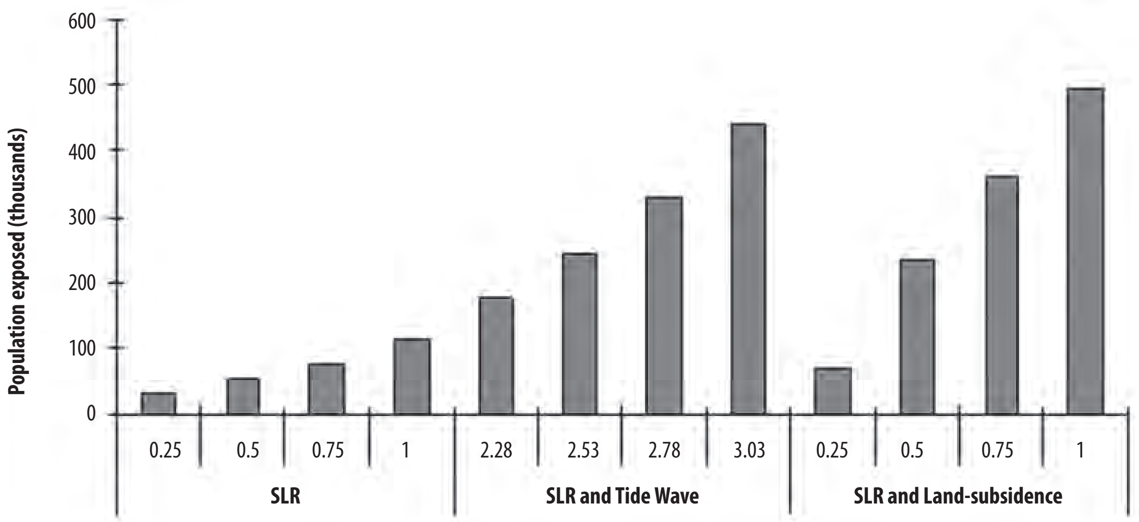


Figure 4.34 The number of residents affected by flooding due to sea level rise and high tide. Source: Hariarti *et al.,* 2009

Table 4.14 Impact of sea level rise, high tide and land subsidence on the population and land use in Semarang. Source: Hariarti *et al.*, 2009

Scenario		Number of people affected (x 1000)	Economic Loss (billion IDR)				
			Settlement	Rice	Ponds	Harbor/ Airport	Total
SLR (m)	0.25	31	1.12	0.00	0.37	0.00	1.49
	0.50	51	1.49	0.00	0.65	0.00	2.14
	0.75	77	1.76	0.00	0.94	0.00	2.69
	1.00	114	2.08	0.00	1.24	8.76	12.08
SLR + high tide (m)	2.28	177	1.12	0.00	2.12	0.00	3.25
	2.53	244	1.49	0.01	2.13	0.00	3.63
	2.78	330	1.76	0.01	2.14	0.00	3.91
	3.03	443	2.08	0.01	2.15	8.76	13.00
SLR + land subsidence (m)	0.25	69	2.54	0.00	0.83	0.00	3.37
	0.50	235	6.15	0.00	1.30	0.00	7.45
	0.75	360	7.61	0.01	1.67	59.91	69.19
	1.00	495	8.77	0.01	1.92	367.53	378.22

SURABAYA CITY

Based on sea level rise of 0.25 m to 1.00 m (Scenario 1), the area of flooding in Surabaya will be less than 2,000 ha, but if it is combined with high tide, a 2.91 m rise (Scenario 2), the area of flooding will reach 10,000 ha (Figures 4.35 and 4.36). The sub-districts which will suffer the most from flooding will be Sukolilo, Gunung Anyar and Rungkut, in that order. Visual observations using satellite imagery and Google Earth found that the areas most under threat from sea level rise are settlements. In addition to settlements, the other land uses potentially affected by flooding are paddy fields, ponds and other infrastructure. The number of people threatened by flooding under Scenarios 1 and 2 will be less than 150,000 and more than 700,000 people, respectively (Figure 4.37).

The expected economic loss due to flooding is presented Table 4.15. For Scenarios 1 and 2, the total economic loss due to sea level rise of 0.25 m will be about 133 billion IDR and 145 billion IDR, respectively. There is only a slight increase from Scenario 1 to Scenario 2. As described previously, this is due to the differences in the nature of flood inundation in Scenario 1 and 2whereas the floods are permanent in Scenario 1 and only temporary in Scenario 2.

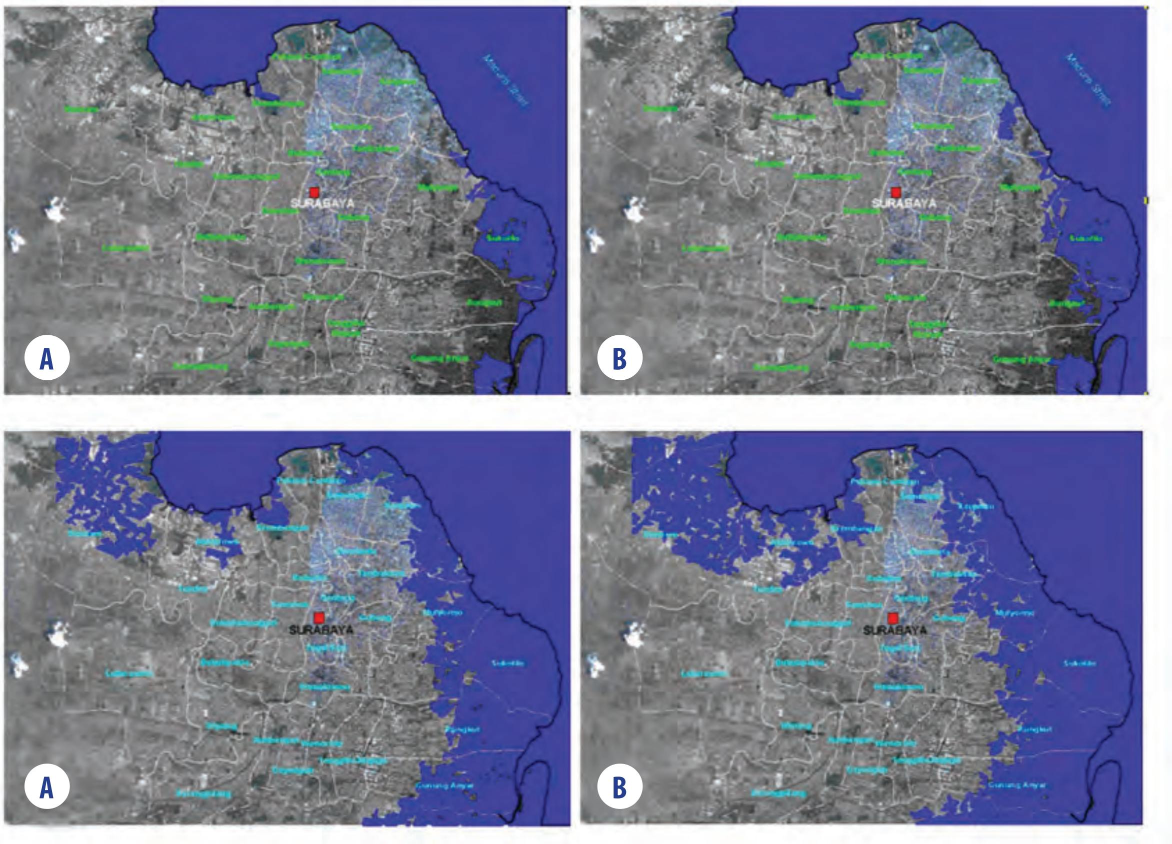


Figure 4.35 Distribution of floods based sea level rise of 0.25 m (A), 1.0 m (B), and sea level rise + high tide equal to 3.16 m (C) and 3.91 m (D) in Surabaya. Source: Hariati *et al.*, 2009

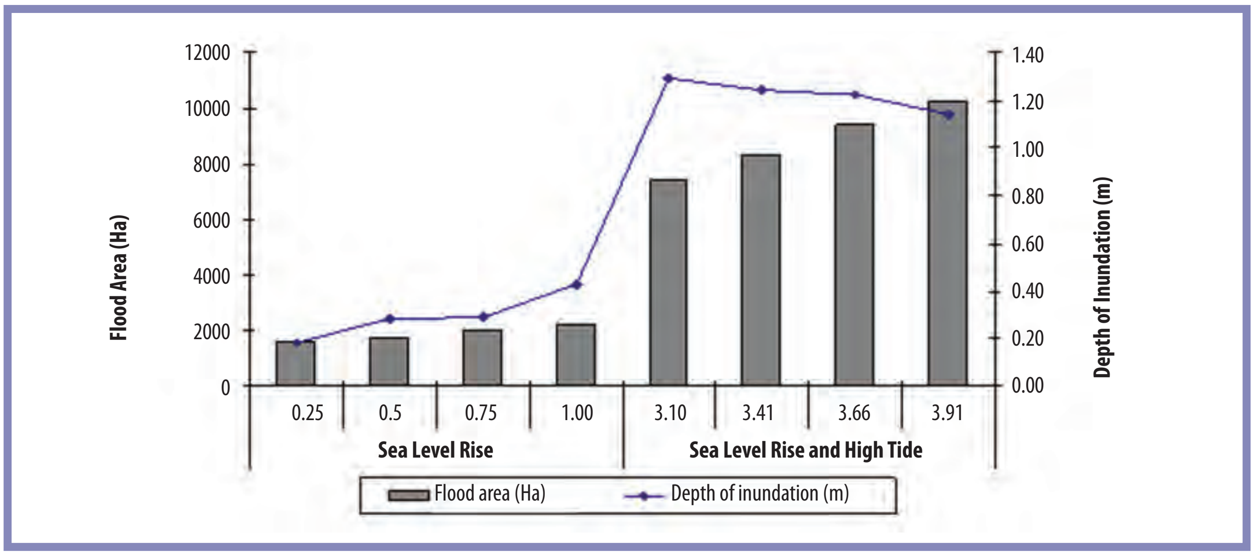


Figure 4.36 Flood area and flood depth due to sea level rise and high tide in Surabaya.
Source: Hariati *et al.*, 2009

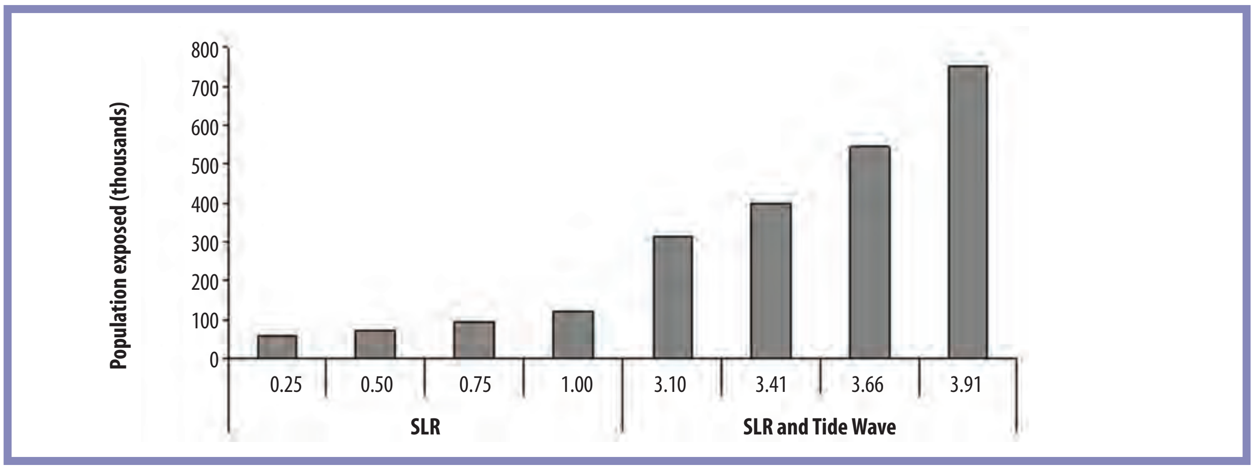


Figure 4.37 The number of residents affected by flooding due to sea level rise and high tide in Surabaya.
Source: Hariati *et al.,* 2009

Table 4.15 Impact of sea level rise and high tide on population and land uses in Surabaya.
Source: Hariati *et al.*, 2009

Scenario		Number of people affected (x 1000)	Economic Loss (billion IDR)				
			Settlement	Rice	Ponds	Harbor/ Airport	Total
SLR	0.25	61	0.34	0.00	4.01	128.52	132.87
	0.50	73	0.40	0.00	4.27	141.36	146.03
	0.75	96	0.56	0.19	4.53	191.06	196.34
	1.00	122	0.68	0.22	4.95	316.61	322.46
SLR + tides and wave action	3.16	310	0.34	4.22	11.65	128.52	144.73
	3.41	401	0.40	4.58	12.51	141.36	158.84
	3.66	546	0.56	4.83	13.03	191.06	209.49
	3.91	751	0.68	5.18	13.56	316.61	336.03

The increase in sea level by approximately 25 to 50 cm in 2050 and 2100, respectively, as projected by many models, will inundate many parts of the coastal cities of Indonesia. Land subsidence will exacerbate this, increasing the total area that will be permanently inundated. Between 25% and 50% of the total area in coastal cities such as Medan, Jakarta, Semarang, and Surabaya will be permanently underwater. The increase of sea level rise may also inundate the outer islands of the country, thereby reducing the size of Indonesian territory. The analysis suggests that an increase in sea level of 50 cm will not inundate the outer islands of Indonesia permanently, however, combined with tidal patterns in the region, five outer islands will be temporarily inundated. These islands include Alor (next to Timor Leste), Pelampong (next to Singapura), Senua (next to Malaysia), Simuk and Sinyaunyau (next to India).

Some of adaptation measures done in the cities (among other places) to cope with flooding from sea level rise, tides and extreme waves include:

1. Development of dike sequipped with polder system to protect area behind the dike (see Figure 4.38);
2. Mangrove rehabilitation in an effort to increase soil surface and reduce wave energy destruction so that the rate of erosion can be reduced; and
3. Practicing fish culture using sylvofishery.

Figure 4.38 Construction of a dike to reduce flooding from high tides and extreme waves in East Harbour of Muara Bary, Jakarta. Source: Media Indonesia, 2007

4.4.5 Health

The impact of climate change can be learned from the influence of climate variability, especially related to extreme climatic conditions. The effects of climate variability and change on human life can be grouped into two (Tromp, 1980): (a) direct climate effects (effects on body physiology and psychology) and (b) indirect climate effects (effects on almost all aspects of life and environment that ultimately affect humans). According to Patz et al. (2003) from the World Health Organization (WHO), climate change and variability can affect:

1. mortality, physical injury, physical and mental health (directly); and
2. changes in biological processes and ecological impacts on food security such as food sufficiency status and resilience of human body, the quality of water resources, and transmission of infectious diseases and water-borne diseases(indirectly).

Climate change, combined with environmental and behavioral changes in society, causes pressures on public health conditions in Indonesia that have become increasingly difficult to overcome. Indonesia suffers from some vector borne diseases, which may become more severe, especially during extreme climatic periods, as experienced by other developing countries. Transmission periods and distribution areas change and the types of diseases become more varied. Increasing cases and changing patterns of disease distribution during extreme climate periods are an indication of the influence of climate change on public health. Among the ten highest ranked health cases illustrated by the number of patients who were treated at the State Hospitals in Indonesia in 2006 (Table 4.16), outbreaks of dengue fever, malaria, leptospirosis and diarrhea were found to be significantly correlated with the occurrence of extreme climate events associated with ENSO.

Table 4.16 The ten main of health problems recorded by hospitals in Indonesia in 2006 (Source: Ditjen Pelayanan Medik - Ministry of Health, 2006)

No.	Health Problem	No. of Cases	% of total Health cases	Magnitude Impact of climate change
1.	Diarrhea, Gastroenterities infection	177,517	9.95	> 50 %
2.	Dengue fever	81,392	3.64	> 80 %
3.	Tiphoid and paratifoid	72,804	3.26	
4.	Obstetrics and gynecology problems	63,580	2,85	
5.	Intracranial injury	48,645	2.18	
6.	Fever by unknown cause	46,175	2.07	
7.	Multiple injury	46,081	2.06	
8.	Pneumonia	37,634	1.69	> 80 %
9.	Malaria	36,865	1.65	> 90 %
10.	Dyspepsia	34,029	1.52	

Cases of dengue fever were found to increase significantly during La Niña years (Figure 4.39) when seasonal rainfall levels were above normal. A significant upward trend in the number of dengue cases was also observed in Java, especially in large cities (Figure 4.40). In other cities, such as Dhaka (Bangladesh), cholera cases correspond significantly to local maxima in ENSO, and this climate phenomenon accounts for over 70% of disease variance (Rodo *et al.*, 2002). In Africa, malaria disease outbreaks were triggered by the occurrence of above normal rainfall (Moji *et al.*, 2002).

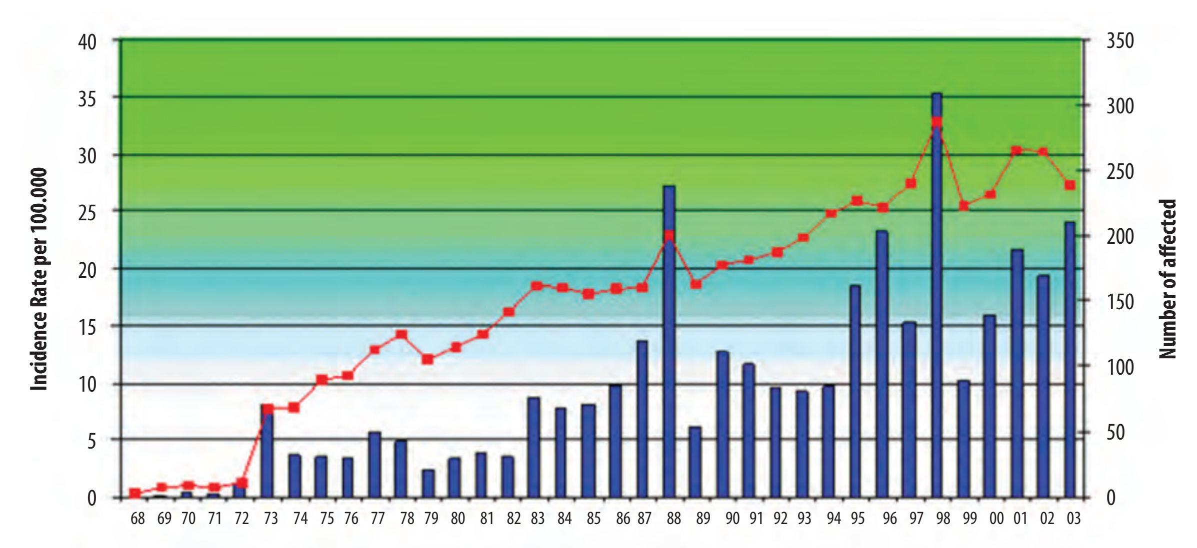


Figure 4.39 Incidence rate of dengue fever and the number of affected cities and districts in Note: 1973, 1988 and 1998 were La Niña years. Source: Ministry of Health.

To predict how climate change will affect vector borne-diseases such as malaria and dengue fever, the following formula from Reisen (1989) was used:

$$c = \frac{ma^2Vp^n}{-\ln p}$$

- c : vectorial capacity, the number of infective bites received daily by a single host
- m : density of vectors in relation to density of host
- a : proportion of vectors feeding on a host divided by the length of the gonotrophic cycle in days
- V : vector competence
- p : daily survival of vectors
- n : the length of the sporogonic cycle(extrinsic incubation period)

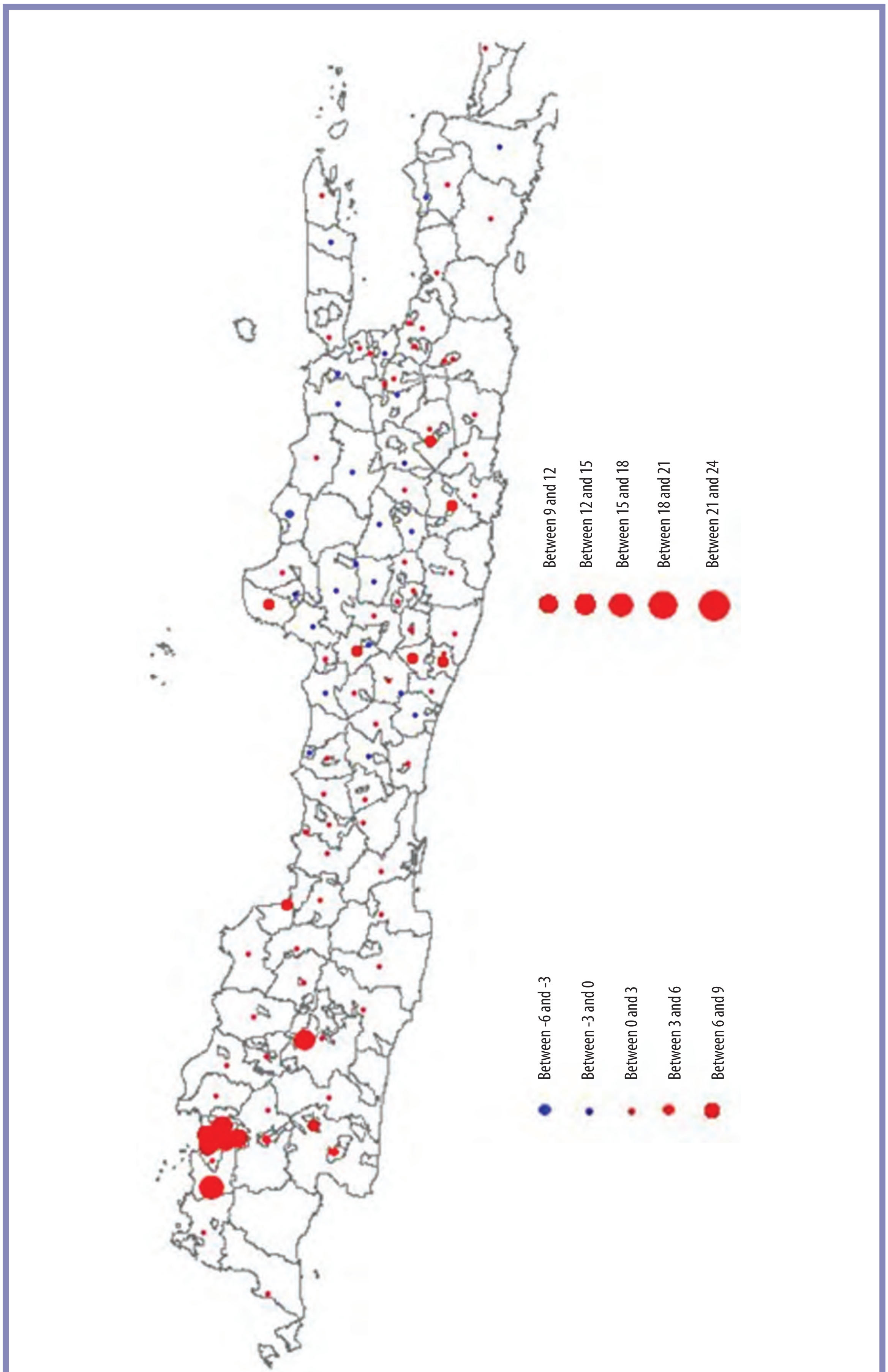


Figure 4.40 Annual trend of dengue incidence rates in districts in Java in period between 1992-2005 (cases per 100,000 people per year). Source: MoE, 2007b.

The transmission risk or transmission potential was predicted by multiplying the vectorial capacity with a correction factor. The following correction factor for malaria (CFm) was developed based on temperature and rainfall using the following formula (Hidayati *et al*., 2009):

$$CF_m = (T_g * T_s)*(R_s * R_{s-})$$

Where Tg will be equal to 1 if air temperature is higher than the base temperature of the gonotropic cycle ($18^{o}C$), otherwise, Tg equal to 0. Ts is equal to 1 if air temperature is higher than the base temperature of the sporogonic cycle ($10^{o}C$), otherwise, Ts equal to 0. Rs is equal to 1 if rainfall is higher than or equal to 25 mm, and equal to R/25 if rainfall is higher than 25 mm. This correction factor was adopted considering the water required for mosquito to lay eggs. For dengue fever, the correction factor was developed based on population density (CFd). The CFd in a particular region is calculated using the following formula (Hidayati et al., 2009):

$$CF_d = W_d/W_{d\_Mataram}$$

Where Wd is the weight of population density for that particular region, Wd is equal to 1 for a region with population density (P) of more than 5000 people/km2, 0.75 for a region where 3000 < P < 5000, 0.5for a region where 1000<P<3000 and 1.4 for a region where P<1000 people/km2. Wd¬_Mataram is the weight of population density of Mataram, a district where a detailed survey on dengue vectors was conducted.

The results of the analysis showed the increasing potential of malaria and dengue fever transmission in 2025 and 2055. The increase in 2055 is not significantly different compared with changes in 2025. Changes in the potential of malaria transmission are predicted to rise much higher than the dengue fever transmission. Under the B1 scenario, changes in the value of transmission potential are predicted to be greater than under the conditions based on the A2 scenario (Table 4.17).

Table 4.17 Percent change in transmission potential for malaria and dengue fever (Hidayati et al., 2009)

Scenario	Malaria		Dengue Fever	
	2025	2055	2025	2055
SRESA2	19	20	4	4
SRESB1	74	85	13	15
Average	46.5	52.5	8.5	9.5

The average potential transmissions (TP) of dengue fever and malaria at present, from 2020-2030 and from 2050-2060 are shown in Figures 4.41 and 4.42. The spatial differences in TP value is much greater than the difference over time, so the difference depicted in the map over time cannot be easily observed.

To minimize the potential impacts of climate change on public health, adaptation measures need to be developed. In general, adaptation efforts in health can be done via six options. Each option has its own operational level, benefits, feasibility and cost barriers (Mc Michael *et al.* 2003; Table 4.18). Some of the adaptations have already been developed. Haryanto (2008) suggest the following adaptation strategies:

1. Improvement of the disease ecology surveillance system and development of early warning system for outbreaks;
2. Enhancement of capacity building for the government, private sectors, civil society institutions related to the prevention and mitigation of public health aspects affected by climate change;
3. Increasing political awareness of the effects of climate change on public health;
4. Empowering community health service systems for the prevention and control of diseases;
5. Conducting research and developing methods for epidemiology and medicine to break the chains of disease transmissions; and
6. Prevention and eradication of contagious and vector-borne diseases affected by climate change.

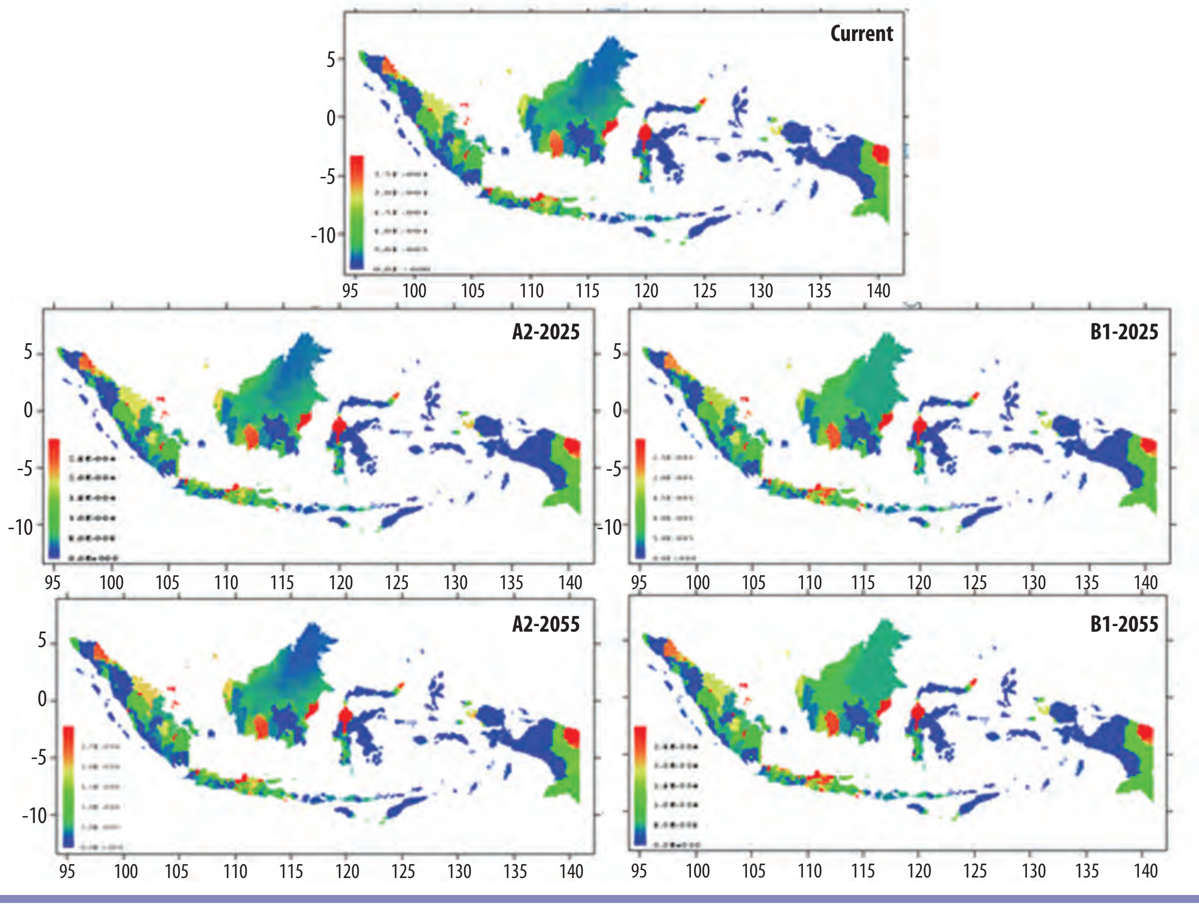


Figure 4.41 Transmission potential of dengue fever under current and future climate (Hidayati *et al.*, 2009). Note: Red represents the highest risk and blue represents the lowest risk

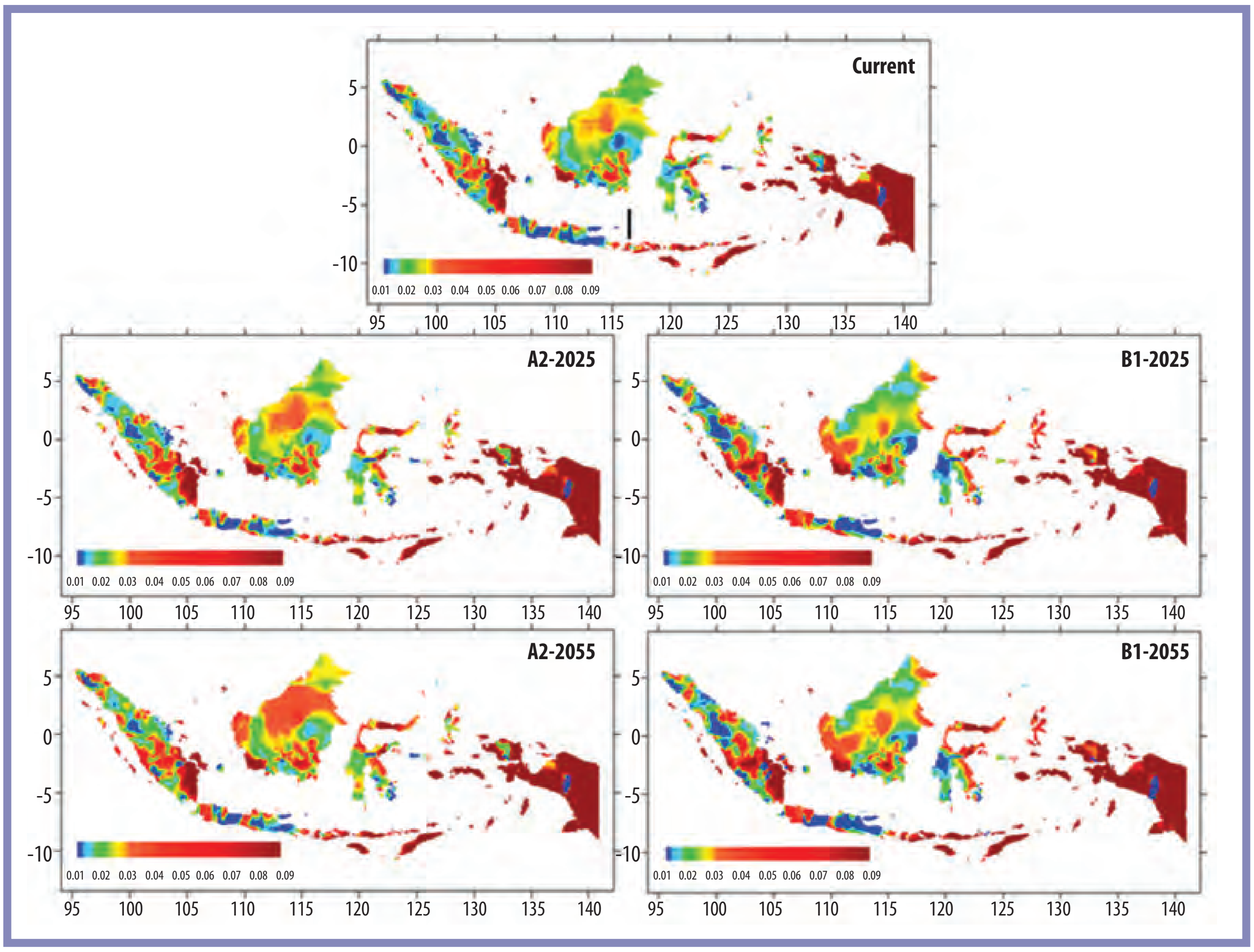


Figure 4.42 Transmission potential of malaria under current and future climate (Hidayati et al., 2009). Note: Red represents the highest risk and blue represents the lowest risk

The Ministry of Health has developed a short-term climate change adaptation program for 2010-2014 (Health Dept., 2009). This includes (i) building a response system for the impacts of climate change on the health sector, (ii) increasing community access to health facilities and services, especially for the poor, (iii) carrying out training programs on health services for community, (iv) building an emergency response system on disasters and extraordinary events, and (v) carrying out disease prevention and control programs.

As climate change will generally increase the intensity and extent of area under risk and the possibility of the emergence of new diseases related to climate, current resources may not be enough. Some of the important aspects that have to be improved to increase the resilience of the health sector to the current and future climate risks are (i) implementation of existing laws/ regulations, (ii) accurate early warning system related to climate-induced health problems, (iii) adequate mass health centers in each susceptible area, (iv) map of spatial susceptibility, (v) sufficient medical officers and paramedics in susceptible areas, (vi) medicines and facilities for diagnoses and treatment of victims, (vii) cooperation between various sectors and institutions both within the country and abroad in order to prevent and overcome health problems, (viii) adequate research and results, (ix) fund for carrying out programs (today,the health budget is

Table 4.18 General adaptation options to reduce the potential health impacts of climate change

Adaptation Options	Level	No. of people that benefit	Feasibility	Barriers	Cost
Interagency co-operation	G R N	+++	++	++	+
Improvements to public health infrastructure	NL	+++	+	+	++
Early warning and epidemic forecasting	NL	++	++	+	+
Support for infectious disease control	NL	++	+++	+	+
Monitoring and surveillance	L	++	+++	+	+
Integrated environmental management	L	+	++	+	++
Urban design (including transport systems)	L	+	+	++	++
Housing, sanitation, water quality	L	+	+	+	+
Specific technologies (e.g., air conditioning)	L	+	+++	+	+
Public education	L	+++	+++	+	+

Notes: G = Global, R = Regional, N = National, L = Local, + + + = large effect, + + = medium effect, + = small effect (Source: McMichael et al. 2003)

less than 5% of the gross domestic bruto, (x) surveillance systems, (xi) knowledge, awareness and active and fullparticipation of the community and (xi) the capacity to successfully use climate information in managing current and future risks to public health.

CHAPTER V

Measures to Mitigate Climate Change

To meet the objectives of the Convention, Indonesia has set up various programs to reduce its emissions. The rate of future greenhouse gas (GHG) emissions under the absence of climate change policy – normally referred to as the base case scenario or business as usual (BAU) – has to be developed. This BAU emissions level will be used to determine how much emissions reduction has been achieved by the country through the implementation of climate change mitigation programs. Baseline emissions should be a key consideration in setting GHG emissions targets as a mitigation strategy to respond to global climate change. At a minimum, the emissions target must be less than the baseline level to induce behavior change and new investment. However, there is substantial uncertainty regarding baseline GHG emissions projection. The use of different assumptions and methodologies may result in different projections. In addition, projecting emissions by sector could not be done independently to some extent. Assumptions used in one sector for developing emissions projections should consider the assumptions used by other sectors. For example, the projected increasing demand for agriculture land (i.e., for rice cultivation) in the future should be captured consistently by the forestry sector in projecting its future deforestation rate. However, in the Second National Communication (SNC), the sectors have not been able to develop integrated emissions projections. The following sections describe briefly the sectoral policy on climate change mitigations and sectoral emissions projections.

5.1 Energy Sector

5.1.1 Policy Framework

Renewable energy development in Indonesia is supported through National Energy Policy and Energy Law as well as through Green Energy Policy (2004). The Green Energy Policy is basically an effort to develop a "green" energy system characterized by maximum use of renewable energy, efficient use of energy and clean energy technology such as clean coal technology, fuel cell and nuclear energy.

The Government of Indonesia (GOI) has issued a number of policies and regulations that will directly affect the GHG emissions level of the relevant sector. In Energy Law No. 30/2007, there are several provisions, the implementation of which will affect GHG emissions mitigation – for example, provisions that support energy conservation and the development of new and renewable energy through incentive mechanisms. Implementation of the provisions concerning energy conservation and renewable energy development are to be regulated by a government regulation. The operational provision of this government regulation is under preparation (status June 2009).

a. In 2006, the GOI has launched National Energy Policy under Presidential Decree No. 5/2006 (called PERPRES). One major issue of the policy is the energy supply mix target that was to be achieved in 2006. The energy supply mix target developed was based on domestic resource availability and national energy security objectives. The national energy security objectives are to move away from oil due to declining domestic reserves and maximize the utilization of abundantly available domestic energy resources. More specifically, the energy supply mix target for year 2025 is as follows: To reduce the share of oil from 54.78% (in 2005) to less than 20%
b. To increase the share of natural gas from 22.2% (in 2005) to 30%
c. To increase the share of coal from 16.77% (in 2005) to more than 33%
d. To increase the share of geothermal energy from 2.48% (in 2005) to more than 5%
e. To increase the share of other new and renewable energy, particularly biomass, nuclear, hydropower, solar and wind to more than 5%
f. To develop biofuel to achieve a share of at least 5%
g. To develop liquefied coal to achieve at least 2% (which will start 50,000 barrels per day (bpd) production or 18 million barrels of oil equivalent [MMBOE] in 2020).

It should be noted that although the Government is to increase the share of renewable energy in the national energy supply mix, the share of coal is also to be increased to fulfill the high domestic demand for energy. Therefore, overall, it cannot be guaranteed that total GHG emissions from the supply side will decrease in the future.

In addition to support through the National Energy Policy and Energy Law, renewable energy development in Indonesia is also promoted through the aforementioned Green Energy Policy (2004). The objective of this policy is to develop a "green" energy system that maximizes the use of renewable energy as well as the efficient use of energy and clean energy technology such as clean coal technology, fuel cell and nuclear energy.

In recent developments regarding coal utilization, the Government launched the first crash program for large additional power generation (10,000 MW coal PP), beginning in 2003. The GOI also launched the second crash program for another large additional power generation with 10,000 megawatts (MW) (68% is coal polypropylene [PP], 22% is renewable, and the remaining is 10% is natural gas), beginning in 2007. It can be concluded that in power generation, the contribution from renewable sources will remain low (11% out of the additional 20,000 MW).

The latest policy that supports the development of biofuel in Indonesia is the Biofuel Price Subsidy (2010), where GOI has launched subsidy for biofuel and the obligation of Pertamina (the national oil company) to buy domestic bofuel production. Before the subsidy policy was launched, the Ministry of Energy and Mineral Resources (MEMR) released MEMR Decree No. 32/2008 to regulate (i) supply, utilization and trade of biofuel and (ii) obligation of biofuel utilization in the transport, industry and power sectors. The obligation will be implemented in stages. For example, the biofuel obligation in the transportation sector was 1% in 2009, increasing up to 15% in 2025. This target will be increased every year so that in 2025, the total contribution of biofuel in the energy supply mix will reach 5% of the total energy supply in Indonesia (i.e., ± 22 billion liters), as written in the National Energy Policy.

The subsequent regulations and policies supporting biofuel development include:

- President Instruction No. 1/2006 concerning biofuel supply and utilization and President Instruction No. 10/2006 concerning the establishment of a national team for biofuels development for poverty alleviation and unemployment reduction; the main objectives of these policies are to reduce dependency on fossil fuels and to strengthen national energy security;

- National Standard (SNI) No. 04-7182-2006 for biodiesel, SNI No. DT27-0001-2006 for bioethanol and Director General for Oil and Gas Decree no. 13483K/24/DJM/2006 concerning Biodiesel Specification for Domestic Market;

- Income tax facility and accelerated amortization for investment in specified business sectors or other areas (Government Regulation No. 1/2007) where renewable energy is included in this category;

- Credit facility for bio-energy development and revitalization of plantations (Minister of Finance Decree No.117/PMK.06/2006) for investment and working capital for activities that support efforts to achieve food and energy security, including biofuel development (Minister of Finance Decree No.79/PMK.05/2007).

To boost the utilization of renewable energy for power generation, the GOI has launched several regulations with provisions related to renewable energy. Specific regulations that govern the sale of electricity generated using renewable energy and/or excess power by an entity to PT PLN (the national electricity enterprise) are:

- MEMR Decree No. 1122/2002 concerning small-scale distributed renewable power generation that regulates small-scale power generation (< 1 MW) using renewable energy, in which, if an entity (i.e., small enterprises) wants to sell electricity generated using renewable energy to PLN (the country's public electric utility), then PLN is obliged to purchase the electricity.

- MEMR Decree No. 02/2006 concerning medium-scale renewable power that regulates medium-scale power generation (1-10 MW) using renewable energy or excess power from captive power plants. If an entity (enterprise) wants to sell electricity generated using renewable energy to PLN (the country's public electric utility), then PLN is obliged to purchase the electricity.

- Government Regulation No. 26/2006 concerning supply and utilization of electricity (revision of Government Regulation No. 10/1989) with new provisions, such as open access for transmission, direct purchase/without bidding for renewable and excess power or under emergency situations. Procedures for power purchase and transmission rental are covered in the Ministerial Decree No. 001/2006. One of the articles in the decree regulates procedures for the purchase of electricity from renewable sources. PLN is allowed to do direct appointment (without bidding procedures) for the purchase of electricity that is generated using renewable energy. For non-renewable electricity, PLN's power purchase is based on competition (bidding process).

There are also a number of policies/laws related to energy efficiency (EE). However, the current policy (National Policy 2006) does not explicitly state or mention the target of EE achievement, affected market players of EE or main features of EE. There are no incentives or penalties mentioned in the current policies/laws that are related to EE. The latest national energy policy (Presidential Regulation No. 5/2006) mentions the need to pursue energy conservation in all sectors. The policy aims to reach energy elasticity equal to less than 1 by 2025.

The Government is also implementing an energy pricing policy whereby energy prices are to be adjusted gradually to reflect the economic value of energy. Staging and adjustment of energy prices are to be designed in such a way that it would promote and optimize energy diversification. With regard to incentives, the Government is to provide incentives for efforts leading to the implementation of energy conservation and for the development of alternative energy.

5.1.2 Emissions Projections and Mitigation Measures

In the SNC, energy supply demand projections are used as sources of activity data in the estimation of GHG emissions. The energy supply demand projection model used in the SNC is the same model used in the Indonesian Energy Outlook 2010-2030 (e.g., Dynamic Model developed by Institut Teknologi Bandung, 2009). The model is used to develop energy supply-demand projections under the BAU scenario and mitigation (CLIMATE) scenario. The model is principally similar to other energy projection models (i.e., the Econometric Model, MARKAL-MAED, LEAP, etc.), where the drivers of energy development are gross domestic product (GDP) and population. The GDP and population growth scenario will determine energy demand growth, which in turn will determine energy supply and GHG emissions level. The relationship between energy supply and demand is determined by energy type and conversion technology.

GDP growth is one of the socioeconomic indicators projected by the Government of Indonesia through BAPPENAS (National Summit, 2009). BAPPENAS has released the target of future Indonesian Economic Development for 2015. The GDP of Indonesia is assumed to grow at an annual rate of 5.5% (2005–2010), 6.6% (2010-2014) and reaching 7.2% in 2015. After 2015, it is rather difficult to determine the GDP growth. Several studies assume the average growth in the GDP will be approximately 7.2% between 2015-2030. This figure is slightly higher than those commonly used by other studies (i.e. about 7%). The estimate of the population growth in the SNC used the estimate from the National Bureau of Statistic (BPS, 2009). The population of Indonesia is estimated to reach 273 million in 2025 (growing at 1.05 %/year, on average, by

2025). Assuming that in the future the population will keep growing at the same rate at 0.94%/ year, on average, from 2020-2025, it is projected that the population will reach 286 million by 2030.

Based on the above assumptions, the MEMR developed energy supply/demand projections for Indonesia in the Indonesian Energy Outlook 2010-2030 (Pusdatin-MEMR, 2009b). Three energy projection scenarios from the Indonesian Energy Outlook 2010-2030 were used in the SNC for estimating GHG projections for the energy sector – BAU, mitigation-1 (CLIMATE 1), and mitigation-2 (CLIMATE 2).

The assumptions used in the development of the BAU scenario from the Indonesian Energy Outlook 2010-2030 were developed using existing policies and plans that have been committed by the GOI, namely Crash Programs I and II for Energy Development that have been covered under RUPTL (Business Plan of Electricity Supply) PT PLN 2009-2018 (PT. PLN, 2009), RUKN (General Plan of National Electricity) 2008-2027 (MEMR, 2008), and road map of biofuel development and utilization (although the biofuel development and utilization is assumed still not maximal). Under this BAU scenario, the projected energy supply is shown in Figure 5.1, while the capacity of power plants that need to be developed is presented in Figure 5.2.

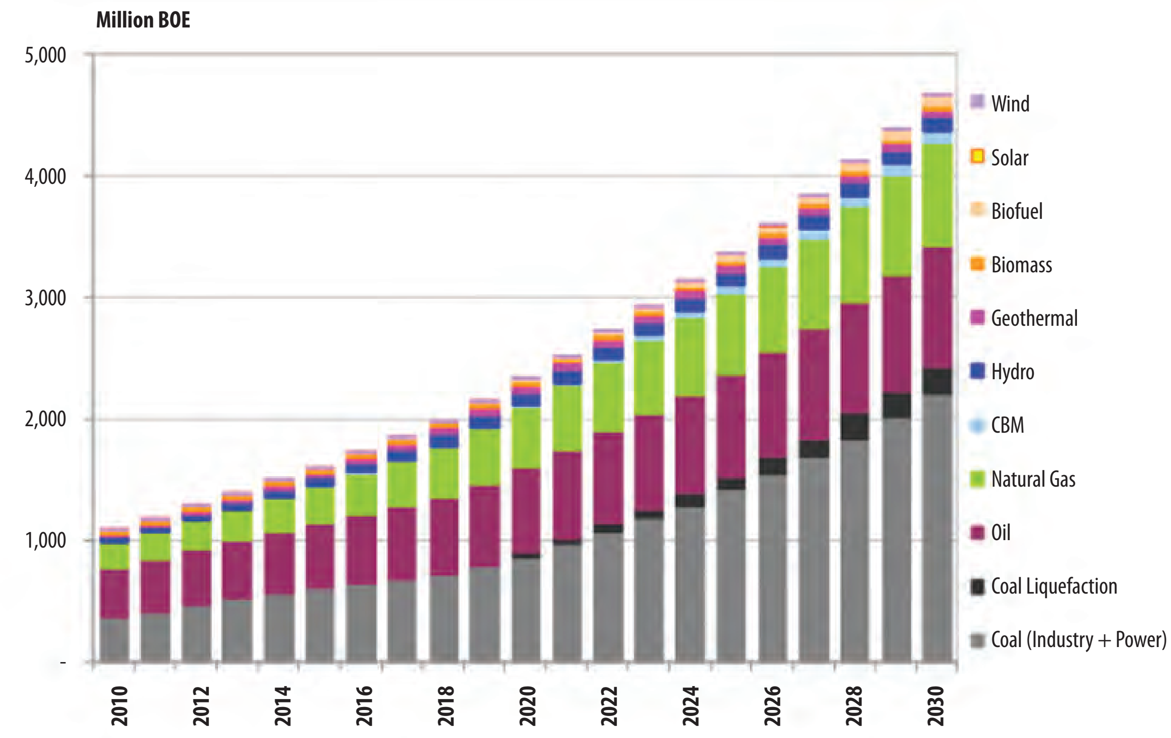


Figure 5.1 Energy projections by type of energy under the BAU scenario, 2010-2030

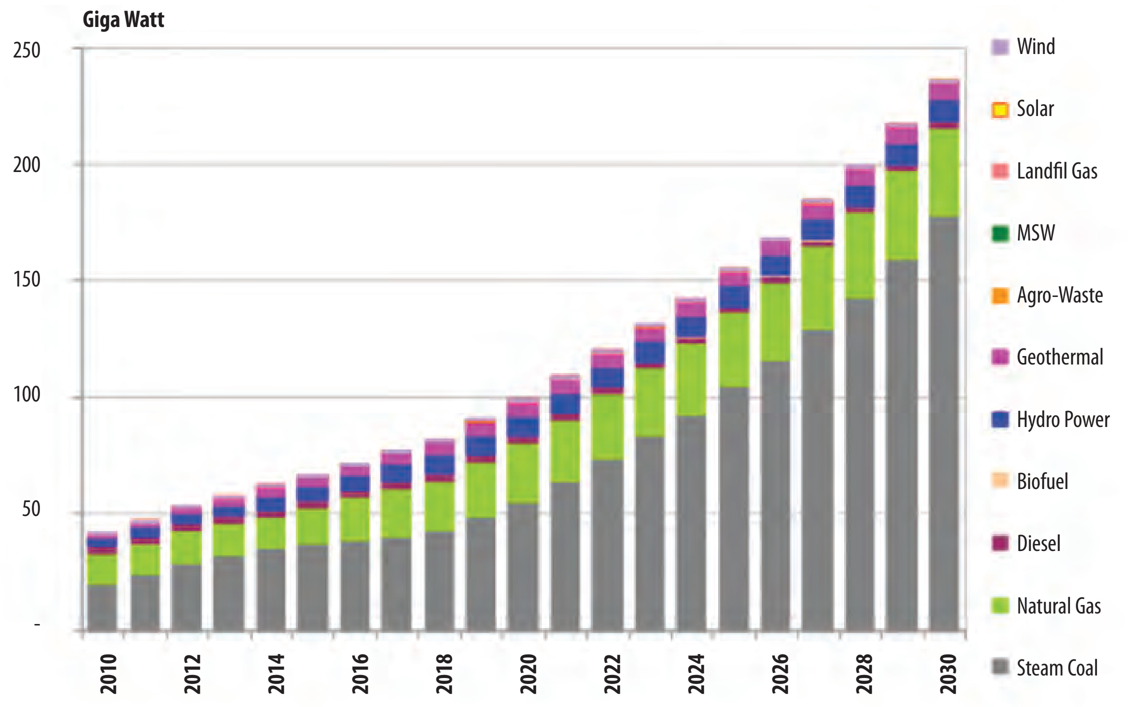


Figure 5.2 Power plant projections by fuel type under the BAU scenario, 2010-2030

In the GHG emissions projections under BAU, it was assumed that development will continue according to the historical trend. The BAU scenario shows how GHG emissions will grow over time in the absence of mitigation policy interventions. Natural energy efficiency and existing national (government and private) plans are considered as components of BAU scenario. The resulting emissions from this scenario in 2025 would reach approximately 1.5 carbon dioxide equivalents (CO_2e), respectively. The rate of annual projected emissions by fuel types and sectors are presented in Figures 5.3 and 5.4, respectively.

The assumptions used for the GHG emissions projections under mitigation scenarios (CLIMATE 1 and 2) are similar to the BAU case with additional assumptions that there will be additional efforts related to energy conservation and new and renewable energy development (i.e., enhance geothermal program, micro-hydro, biofuel, biomass waste to energy, solar PV, wind energy and coal bed methane [CBM]).

Another mitigation scenario used is Presidential Regulation No. 5/2006 - Blue Print PEN 2010, or the PERPRES scenario. The energy supply projection under the PERPRES scenario was developed with an objective to meet energy security. The target of renewable energy in the supply mix is more than 17.93% of the total energy supply. The shift of new and renewable energy from 4.3% in 2005 to 17.93% in 2025 is positive for climate change mitigation, however, the increase in coal share from 19.4% in 2005 to 34% coal and 3.56% liquefied coal by 2025 will negatively

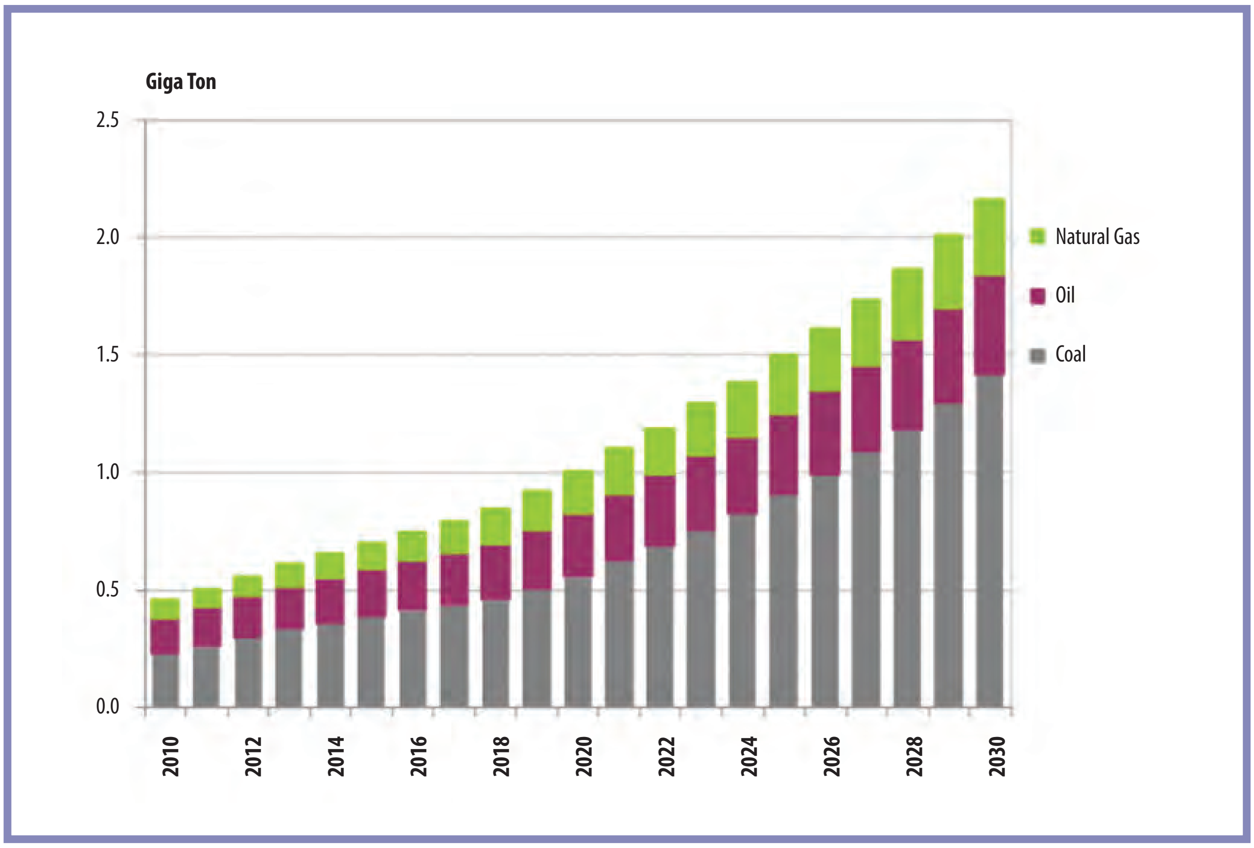


Figure 5.3 Projection of GHG emissions generation by fuel type under the BAU scenario, 2010-2030

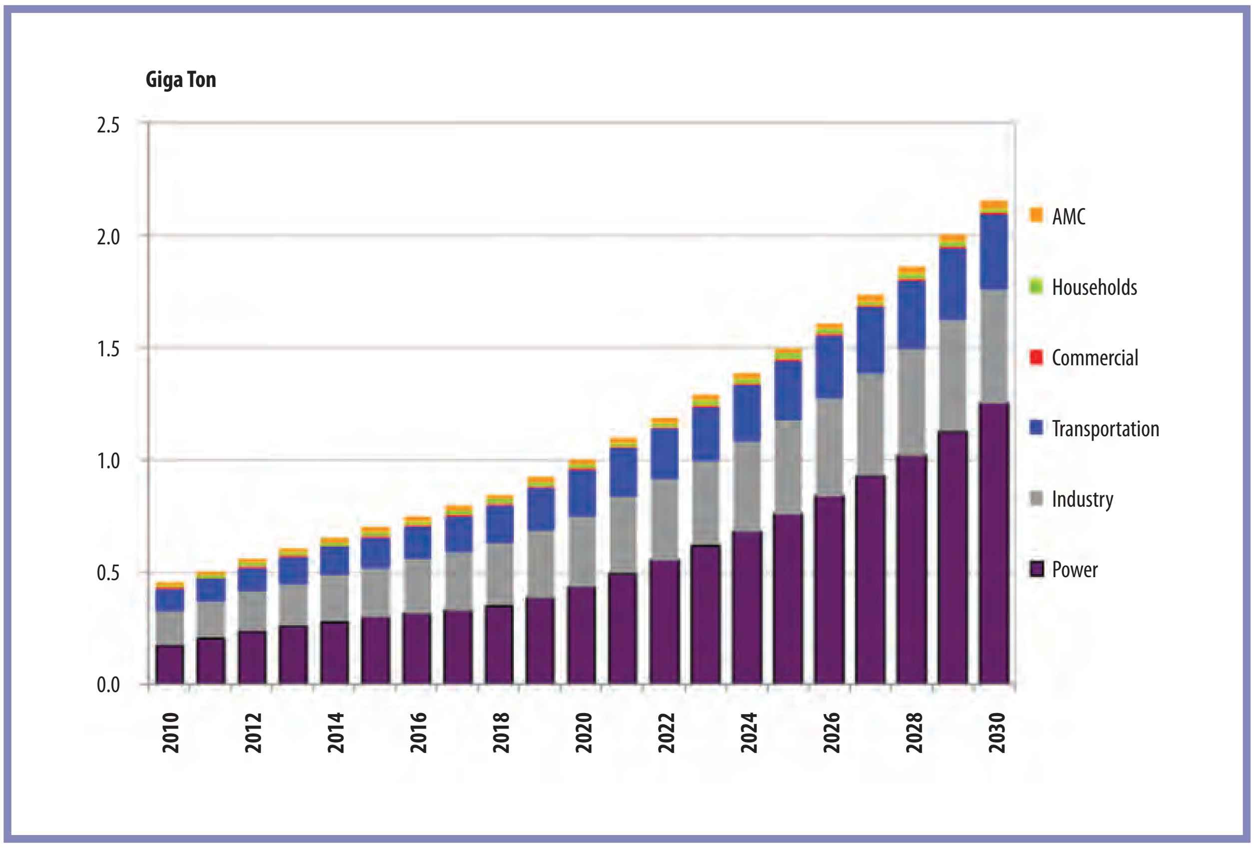


Figure 5.4 Projection of GHG emissions generation by sector under the BAU scenario, 2010-2030

affect climate change mitigations so that there is little net decrease in GHG emissions. The energy supply mix under the PERPRES scenario is formulated based on least cost and resource availablity.

Both the CLIMATE 1 and CLIMATE 2 mitigation scenarios and PERPRES scenario have excluded advanced clean coal technologies (i.e., integrated gasification combined cycle [IGCC]) and carbon capture and sequestration [CCS]) because these technologies are considered to be very expensive. The clean coal technologies considered under both scenarios are fluidized bed, sub-critical and super-critical coal power plants.

The primary energy supply mix, sectoral energy demand, and power plant development projections along with the carbon dioxide (CO2) emissions under the BAU, the two mitigation scenarios (CLIMATE 1 and CLIMATE 2), and PERPRES scenario (for comparison) are presented in Table 5.1, Table 5.2, Table 5.3, Figure 5.5, and Figure 5.6. Table 5.1 presents the projection of primary energy supply mix (by fuel type), Table 5.2 presents the projection of final energy demand by sector and Table 5.3 presents demand projection of installed capacity of power generation. These projections are developed using dynamic models with several assumptions, as was discussed previously.

Figures 5.5 and 5.6 show that there are potential reduction in the CO2 emissions projections under the CLIMATE 1, CLIMATE 2 and PERPRES scenarios compared to the BAU scenario. The potential of CO2 emissions reductions for each scenario is presented in Figure 5.7. The potential CO2 emissions reduction by 2020 under the CLIMATE 1 scenario is approximately 0.18 Gton CO2e, or approximately 18% of the BAU emissions; under the CLIMATE 2 scenario, the potential emissions reduction is approximately 0.28 Gton CO2e, or approximately 28% of the BAU emissions. Under the PERPRES scenario, the CO2 emissions reductions by 2020 will reach 0.1 Gton CO2e, or 10% of BAU emissions. By 2025, the CLIMATE 1, CLIMATE 2, and PERPRES scenarios will result in a 20% reduction (0.3 GTon CO2e), 31% reduction (0.47 Gton CO2e) and 21% (0.31 Gton CO2e), respectively.

Table 5.1 Projection of energy supply mix under BAU, CLIMATE and PERPRES scenarios (million BOE)

Type Energy	2010				2015				2020				2025				2030			
	BaU Outlock	CLIMATE 1 Outlock	CLIMATE 2 Outlock	PERPRESS 2009	BaU Outlock	CLIMATE 1 Outlock	CLIMATE 2 Outlock	PERPRESS 2009	BaU Outlock	CLIMATE 1 Outlock	CLIMATE 2 Outlock	PERPRESS 2009	BaU Outlock	CLIMATE 1 Outlock	CLIMATE 2 Outlock	PERPRESS 2009	BaU Outlock	CLIMATE 1 Outlock	CLIMATE 2 Outlock	PERPRESS 2009
Coal	353	353	353	330	600	462	375	482	858	669	495	725	1,412	1,078	751	1,007	2,201	1,677	1,079	-
Coal Liquefaction	-	-	-	-	-	-	-	-	36	36	-	30	110	110	-	91	218	218	-	-
Oil	422	422	422	495	538	515	514	555	699	635	651	627	840	743	786	589	997	841	909	-
Natural Gas	207	207	207	269	302	275	314	349	494	415	460	417	687	527	678	616	841	664	971	-
CBM	-	-	-	-	7	7	7	11	18	18	18	43	64	79	79	96	98	105	105	-
Hydro	45	45	45	15	65	68	78	23	99	100	117	32	102	110	129	39	110	121	140	-
Geothermal	10	10	10	36	36	41	45	90	57	66	69	116	61	74	79	184	66	82	90	-
Biomassa	41	41	41	-	40	39	47	-	38	35	53	-	37	41	58	-	34	52	67	-
MSW	-	2	-	-	-	22	-	-	-	65	-	1	-	111	-	1	-	167	-	-
Biofuel	2	-	2	34	6	0	23	75	15	0	66	170	47	0	113	298	83	0	169	-
Solar	-	-	-	-	-	-	-	-	-	-	1	1	-	0	1	1	-	0	2	-
Wind	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
Nuclear	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	12	-
Total	1.080	1.080	1.080	1.179	1.591	1.429	1.402	1.585	2.314	2.038	1.931	2.162	3.338	2.871	2.674	2.923	4.649	3.927	3.543	-
Efficiency	-	-	-	-	-	10%	12%	-	-	12%	17%	-	-	14%	20%	-	-	16%	24%	-

Notes: Primary energy supply mix under Perpress scenario 2010 – 2025

Table 5.2 Projection of sectoral energy demand under BAU, CLIMATE and PERPRES scenarios (million BOE)

Sector Activity	2010			2015			2020			2025			2030		
	BAU	CLIMATE 1	CLIMATE 2	BAU	CLIMATE 1	CLIMATE 2	BAU	CLIMATE 1	CLIMATE 2	BAU	CLIMATE 1	CLIMATE 2	BAU	CLIMATE 1	CLIMATE 2
Transportation	225	225	225	317	316	316	472	468	467	645	653	624	840	814	780
Industry	386	386	386	564	512	505	828	691	649	1,124	915	863	1,423	1,138	1,076
Households	273	273	273	313	309	309	370	362	362	417	402	402	440	417	417
Commercial	47	47	47	54	51	50	68	59	57	87	76	73	127	108	104
ACM	39	39	39	46	46	46	54	54	54	65	65	66	86	86	86
Total	970	970	970	1,292	1,233	1,226	1,790	1,633	1,589	2,339	2,093	2,028	2,915	2,562	2,463
Efficienty Potential															
- Transportation					0%	0%		1%	1%		2%	3%		3%	7%
- Industry					9%	10%		17%	22%		19%	23%		20%	24%
- Households					1%	1%		2%	2%		3%	3%		5%	5%
- Commercial					6%	7%		11%	15%		13%	16%		15%	18%
- ACM					0%	0%		0%	0%		0%	0%		0%	0%
TOTAL					5%	5%		9%	11%		10%	13%		12%	16%

Table 5.3 Projection of installed capacity demand of power generation under BAU, CLIMATE 1 and CLIMATE 2 scenarios (in MW)

Sector Activity	2010			2015			2020			2025			2030		
	BAU	CLIMATE 1	CLIMATE 2	BAU	CLIMATE 1	CLIMATE 2	BAU	CLIMATE 1	CLIMATE 2	BAU	CLIMATE 1	CLIMATE 2	BAU	CLIMATE 1	CLIMATE 2
Steam Coal	19,890	19,890	19,890	37,032	26,399	18,997	54,835	42,404	28,363	104,418	82,458	53,180	178,147	142,260	88,627
Natural Gas	12,875	12,875	12,875	15,756	14,474	19,974	25,414	21,832	30,458	31,604	26,874	49,011	37.626	31,657	76,020
Diesel	3,221	3,221	3,221	3,094	2,985	2,998	2,943	2,621	2,798	2,806	2,278	2,295	2,677	2,093	1,894
Biofuel	33	33	33	57	184	296	63	463	614	87	569	765	97	629	812
Hydro	3,746	3,746	3,746	5,382	5,702	6,513	8,211	8,313	9,750	8,479	9,177	10,737	9,171	10,091	11,651
Geothermal	1,093	1,093	1,093	3,875	4,359	4,776	6,060	7,053	7,333	6,475	7,866	8,463	7,055	8,706	9,550
Agro-Waste	100	100	100	95	708	701	172	1,237	1,186	212	1,785	1,718	271	2,304	2,222
MSW	-	-	-	5	5	5	20	20	20	40	40	40	50	50	50
Landfil Gas	-	-	-	-	-	-	3	3	3	10	10	10	20	20	20
Solar	12	12	12	19	19	31	40	40	96	62	62	178	76	76	288
Wind	1	1	1	3	3	3	7	7	8	12	12	17	20	20	30
Nuclear															4,000
TOTAL	40,969	40,969	40,969	65,318	54,838	54,295	97,768	83,993	80,630	154,204	131,130	126,415	235,210	197,906	195,164

Note: There is no power generation projection plan under the PERPRES scenario for 2010-2030

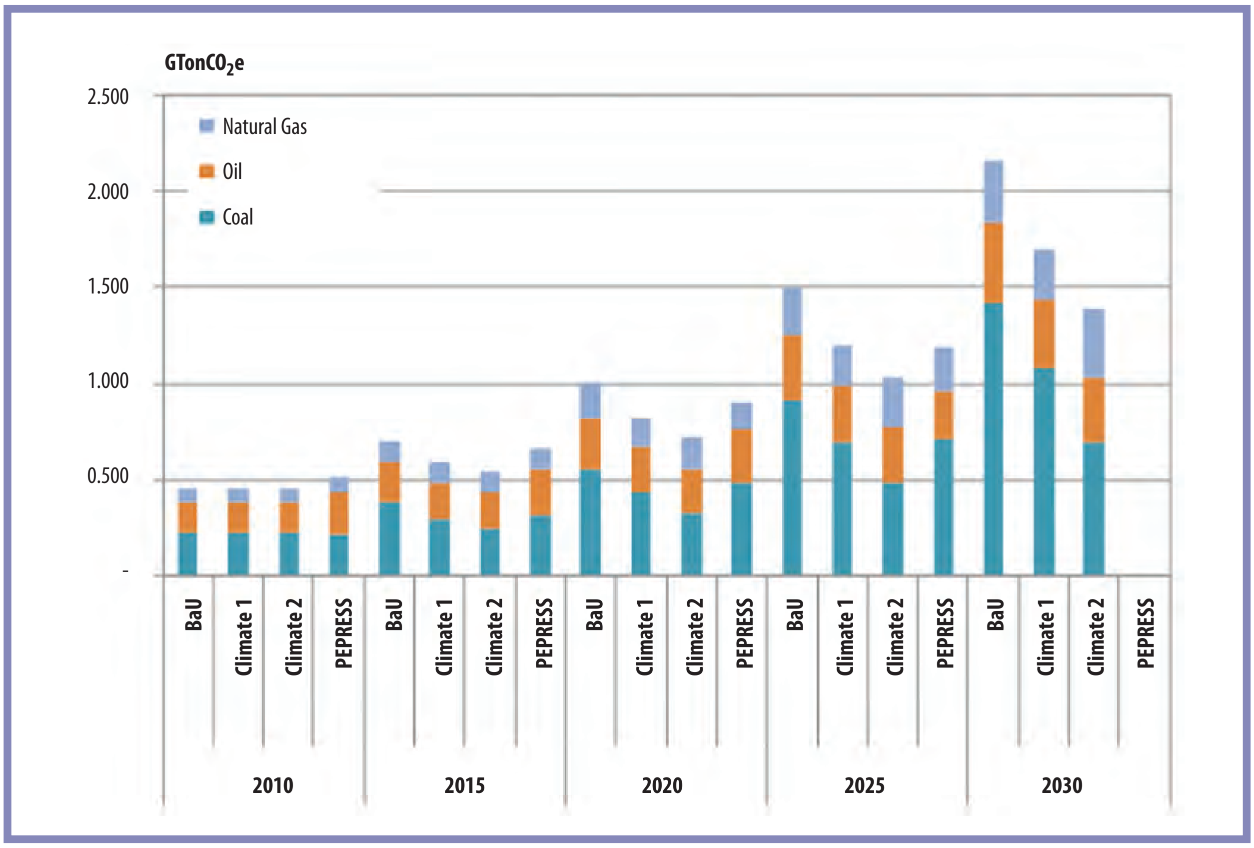


Figure 5.5 GHG emissions projections by fuel type under BAU, CLIMATE and PERPRES scenarios

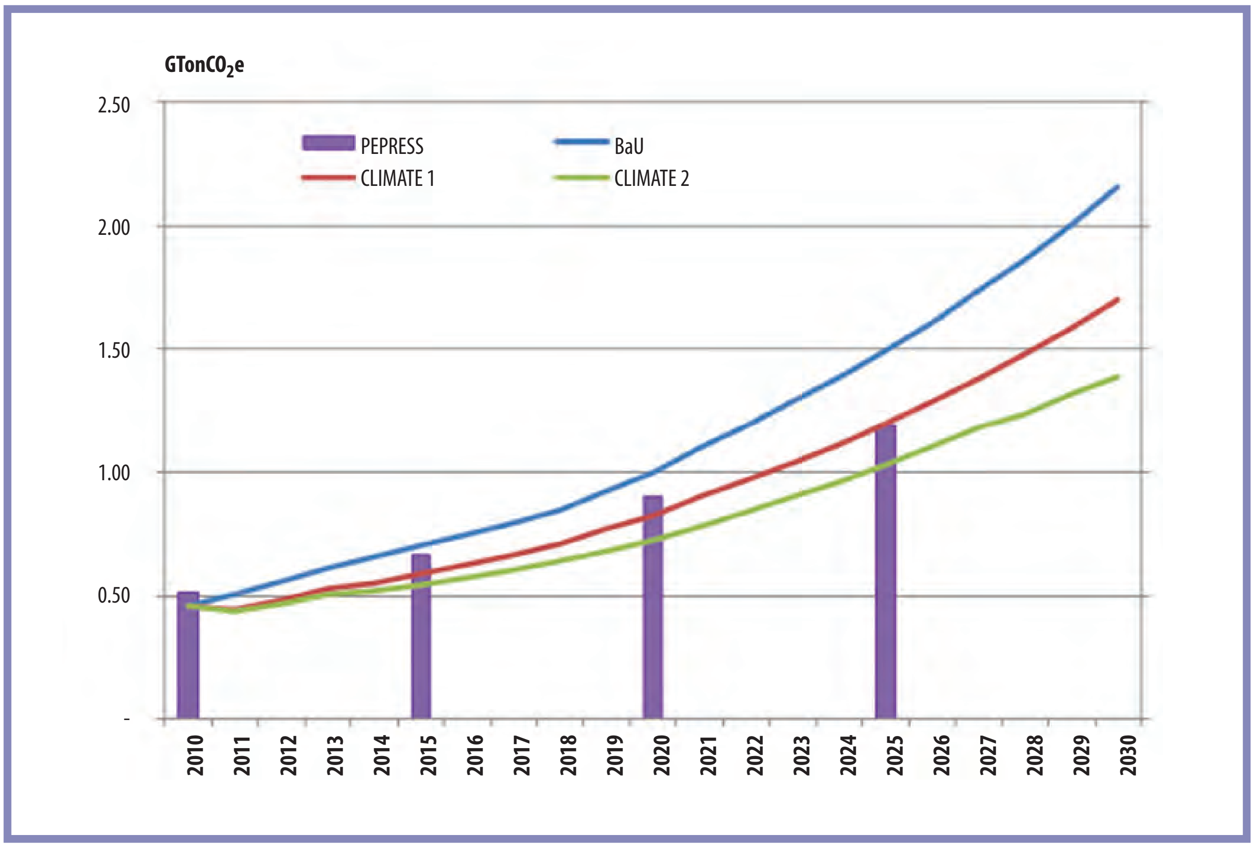


Figure 5.6 Total GHG emissions projections under BAU, CLIMATE and PERPRES scenarios

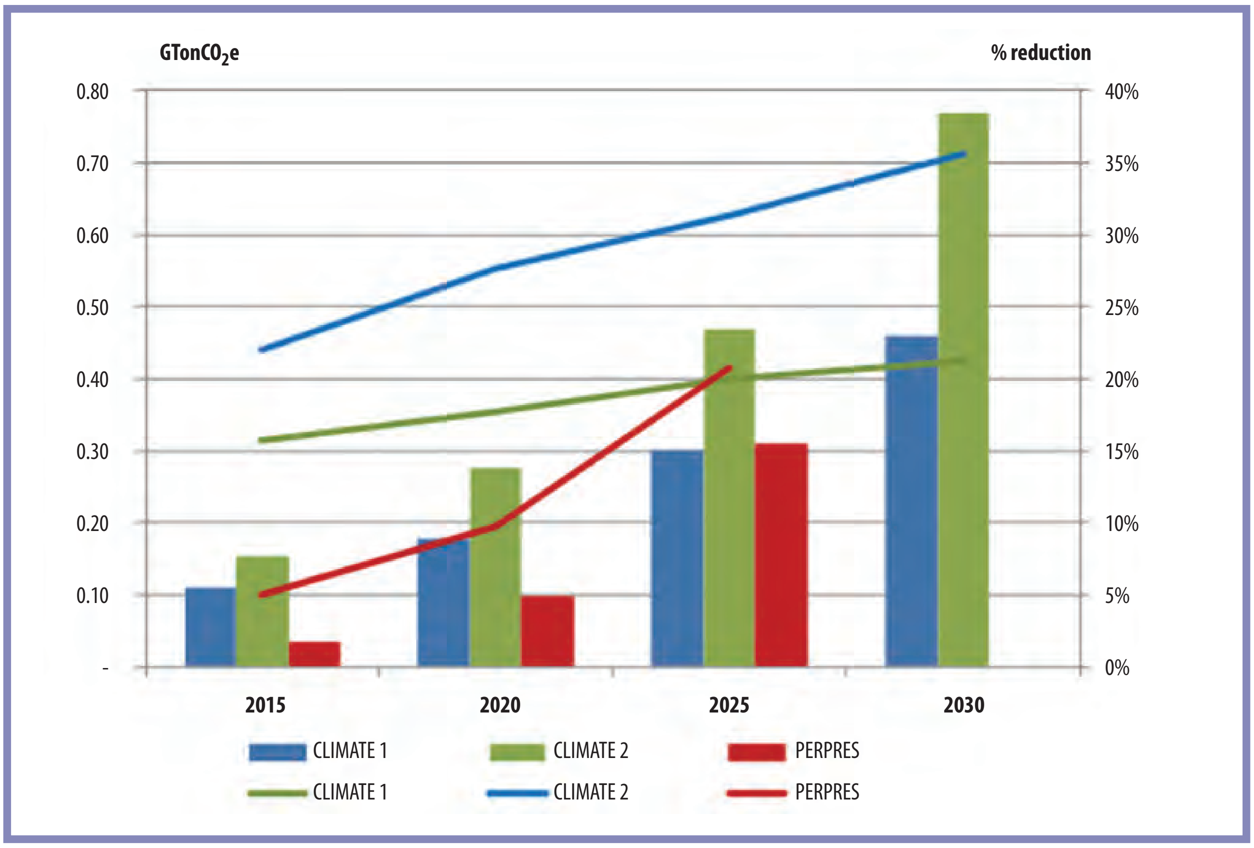


Figure 5.7 GHG emissions reduction potential under BAU, CLIMATE 1, CLIMATE 2, and PERPRES scenarios

In selecting mitigation measures, factors considered were as follows: (i) sectors that consumed a significant amount of fossil energy, especially with high GHG emissions, such as coal and other fossil fuels, (ii) magnitude of GHG emissions reduction potential of a technology for a given demand and (iii) maturity of the technology to be used for mitigation. Based on these considerations, several mitigation options have been selected, as shown in Table 5.4. Not all of these options are included in the CLIMATE scenarios. The CLIMATE scenarios are developed by considering the domestic resources potential and technological and financial limitations in acquiring more advanced mitigation approaches, such as CCS and advanced clean coal technology.

In addition to that, the selected options also consider that Indonesia is not an Annex I country, and therefore has no international obligation to reduce GHG emissions. However, the GOI released a statement that Indonesia will reduce up to 26% by 2020 with domestic capacity and will further reduce up to 41% by 2020 with international support; this statement is a non-binding GHG emissions reductions statement. It should be noted that the selected mitigation options could be sufficient to achieve the above mentioned emissions reduction statement (26% by 2020). Emissions reductions, which can be achieved from the selected mitigation options under the CLIMATE scenario, are the differences between the emissions projections under the BAU scenario and the emissions projections under the CLIMATE scenarios. The GHG emissions difference level between the BAU scenario and CLIMATE scenarios is more appropriately referred to as "emissions avoidance."

Table 5.4 Selected mitigation options

Sector	Sub-sector	Mitigation Options
Energy Supply	Power generation	a. Include the energy system with fewer GHG emissions that has not been selected in BAU, such as biomass-based power (electricity generation from municipal solid waste [MSW] incineration, , landfill gas (LFG), liquid and solid biomass waste, etc.), solar, wind, etc., although the share of these types of energy is still relatively very small; b. Increase the share of new and renewable energy that has been included in BAU, but is still below the level of PERPRES target, such as geothermal and nuclear energy; c. Increase the use of efficient technology in power plants, such as circulated coal fluidized bed combustion (CFBC), sub- or super-critical power plants, coal IGCC, gas combined cycle, combined heat and power; d. Develop technology that is appropriate for utilizing fuels with low GHG emissions (i.e., natural gas); and e. CCS technology application for large coal power plants.
	Oil and gas production and refineries	Gas flaring and venting reduction
Energy End User	Transportation	a. Increase biofuel development efforts for personal vehicles b. Increase the use of compressed natural gas and liquified petroleum gas (LPG) in transportation c. Introduce fuel cell vehicles and electric cars/motorcycles d. Promote mass rapid transport (MRT) e. Traffic management, etc. (Appendix 3 presented a policy and air control program issued by the Directorate General of Land Transportation, Ministry of Transportation to reduce air pollution due to exhaust gas from vehicles)
	Industry	a. Increase the use of more EE equipment or technology (i.e., more efficient conversion process, more efficient combustion system, variable speed electric motors, etc.) b. Increase the use of more efficient material conversion process c. Increase the use of recycled materials, etc. d. Introduce co-processing or co-firing technology
	Residential and commercial end uses	BAU, CLIMATE 1 and CLIMATE 2 scenarios and is therefore also considered as a mitigation option

Under the CLIMATE mitigation scenarios, there are three important options to reduce GHG emissions levels: (i) efficiency energy (demand side as well as power supply side), (ii) promoting biofuel to replace the utilization of fossil fuels (refinery products) and (iii) the utilization of renewable energy in power generation (geothermal, biomass based fuels, hydro, etc.). Detailed mitigation scenarios and investment costs will be discussed in the following sub-sections.

5.1.3 Mitigation Costs

The estimated investment costs needed for implementation of the mitigation options includes (i) development of biofuel production to supply energy demand in the Indonesian transportation sector, (ii) development of advanced coal power plants (more efficient) and less GHG emitting power plants (i.e., natural gas power generation), (iii) develop other renewable energy (e.g., geothermal, hydropower, biomass-based power plants, municipal solid waste [MSW]-based power plants, etc.) and (iv) increasing efficiency on the energy demand side.

Biofuel Production for the Transportation and Industrial Sectors

Recently, biofuels have become one of the most important forms of energy in Indonesia, particularly in the transportation and industry sectors. According to the GOI's plan, the future demand of biofuel in the transportation and industry sectors will be supplied from domestic production. Figure 5.8 presents the demand of biofuel in Indonesia and total investment for the production systems. The total investment cost is estimated based on the investment cost of 30 million USD per 300,000 tons per year. Table 5.5 presents additional investment costs and the potential reduction of GHG emissions.

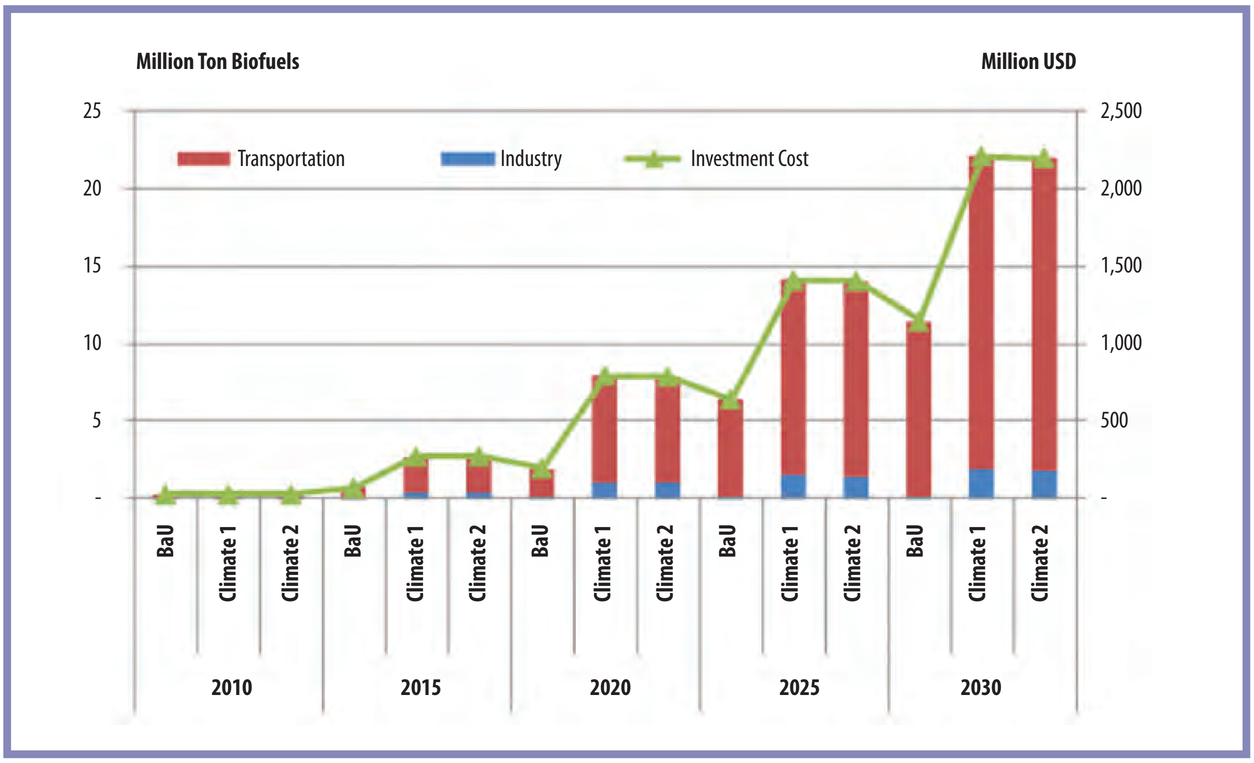


Figure 5.8 Total projected demand of biofuel in the transportation and industrial sectors and estimated investment cost of the biofuel production system

Table 5.5 Additional demand of biofuel and GHG emissions reduction potential and cost

Year	Biofuel Add. Demand (from 2010), BEO			Reduction Potential, Ton CO_2e		Additional Cost, Million USD		Av. Reduction Cost, USD/ton	
	BAU	CLIMATE 1	CLIMATE 2	CLIMATE 1	CLIMATE 2	CLIMATE 1	CLIMATE 2	CLIMATE 1	CLIMATE 2
2015	3,095,690	17.579.525	17,541,791	6,314,952	6,298,500	203	202	32.11	32.11
2020	12,079,552	54.632.308	54.197.991	12,238,050	12,065,140	393	387	32.11	32.11
2025	43,808,831	98,695,064	98,100,635	5,377,396	5,307,587	173	170	32.11	32.11
2030	79,658,232	155,583,732	154,842,779	9,173,120	9,109,236	295	292	32.11	32.11

Advanced (more efficient) coal power plants

Table 5.6 presents new investments for advanced (more efficient) coal power plants under the BAU, CLIMATE1 and CLIMATE 2 scenarios. The size and investments made for new additional power plants under CLIMATE 1 and 2 are both lower than under the BAU scenario. The reduced use of coal plants is the result of two factors: reduced demand for power plant capacity due to conservation efforts and the shift of power plants from coal-based to natural gas power plants (i.e, less GHG emitting power plants) and to renewable power plants (geothermal, hydropower, solar, wind, biofuel, biomass wastes). The table also shows that new coal power plants in Indonesia in the neear future (until 2030) will consist of two types: advanced coal (efficiency of 38%) and conventional coal (efficiency of 32%). As a result of reduced use of coal power plants and the use of advanced coal power plants GHG emissions from coal power plants for the CLIMATE 1 and CLIMATE 2 scenarios are both lower than that of the BAU.

Table 5.6 New investments for advanced (more efficient) coal power plants under the BAU, CLIMATE1 and CLIMATE 2 scenarios

Year	BAU					CLIMATE 1					CLIMATE 2				
	Installed Cap	New power plant, M/V		Investment	Emission	Installed Cap	New plant, M/V		Investment	Emission	Installed Cap	New plant, M/V		Investment	Emission
		Advanced	Conventional				Advanced	Conventional			MW	Advanced	Conventional		
	MW	Eff 38%	Eff 32%	million USD	mill.ton CO_2e	MW	Eff 38%	Eff 32%	million USD	mill.ton CO_2e	Climate 2	Eff 38%	Eff 32%	million USD	mill.ton CO_2e
2010	19,890				133	19,890				133	19,890				133
2011	24,131	-	4,241	5,089	161	19,890	-	-		110	19,890				98
2012	28,630	-	4,499	5,399	191	19,890	-	-		125	19,890				108
2013	32,249	-	3,619	4,343	215	22,359	-	2,469	2,962	149	19,890				117
2014	35,043	-	2,794	3,353	234	23,897	1,539	-	3,077	155	19,890				118
2015	37,032	-	1,989	2,387	247	26,399	2,502	-	5,004	171	19,890				123
2016	38,896	-	1,864	2,237	260	28,329	695	1,235	2,872	183	19,949	59	-	118	129
2017	40,575	-	1,679	2,015	271	31,024	269	2,425	3,449	201	21,052	1,103	-	2,206	136
2018	42,782	-	2,207	2,648	285	33,801	278	2,499	3,554	219	23,153	2,101	-	4,201	150
2019	48,609	4,079	1,748	10,256	319	38,050	4,250	-	8,499	243	25,648	2,495	-	4,990	163
2020	54,835	623	5,603	7,968	360	42,404	1,089	3,266	6,096	270	28,363	1,494	1,222	4,454	181
2021	64,063	923	8,305	11,812	421	49,724	1,757	5,563	10,188	317	32,683	864	3,455	5,874	208
2022	73,482	5,652	3,768	15,825	475	57,070	6,612	735	14,106	358	37,473	4,311	479	9,197	235
2023	83,145	1,933	7,730	13,142	538	65,110	8,040	-	16,080	397	42,579	5,106	-	10,213	260
2024	92,172	1,805	7,221	12,276	596	72,470	7,360	-	14,721	442	47,345	4,766	-	9,532	289
2025	104,418	2,449	9,797	16,654	676	82,458	7,990	1,997	18,376	503	53,180	4,376	1,459	10,502	324
2026	115,946	2,306	9,222	15,678	750	91,842	3,754	5,631	14,265	560	59,492	2,840	3,472	9,847	363
2027	129,345	2,680	10,720	18,223	837	102,487	5,323	5,323	17,032	625	66,350	3,429	3,429	10,973	405
2028	142,912	2,713	10,854	18,451	925	113,712	5,612	5,612	17,959	694	72,731	3,191	3,191	10,210	428
2029	159,556	3,329	13,315	22,636	1,032	127,034	6,661	6,661	21,315	775	80,553	3,911	3,911	12,515	476
2030	178,147	3,718	14,872	25,283	1,153	142,260	7,613	7,613	24,361	868	88,627	4,037	4,037	12,918	510

Less GHG-emitting power plants

Table 5.7 presents the installed capacity, additional investment and GHG emissions of natural gas power plants from 2010-2030. The installed capacity of natural gas power plants in the CLIMATE 1 scenario is less than that in the BAU scenario. This occurs because the demand of electricity in the CLIMATE 1 scenario is lower than that of the BAU and there is not much effort to shift from coal to natural gas plants. However, as a result of greater efforts to use less GHG emitting plants, the installed capacity of natural gas plants under the CLIMATE 2 scenario is much greater than that of the BAU, especially after 2020. Due to the higher installed capacity of natural gas plants, the required investment and the GHG emissions in the CLIMATE 2 scenario are higher than that of the BAU. Although the GHG emissions of gas power plants are higher in CLIMATE 2, the overall emissions from the power sector in CLIMATE 2 are lower than that of the BAU because the increase in emissions from natural gas plants is compensated by the decrease in emissions from coal power plants.

Table 5.7 The installed capacity, additional investment and GHG emissions of natural gas power plants from 2010-2030

YEAR	BAU			CLIMATE 1			CLIMATE 2		
	Installed Cap, MW	Investment of new plant, Mill. USD	Emissions mill.Ton CO_2e	Installed Cap, MW	Investment of new plant, Mill. USD	Emissions, mill.Ton CO_2e	Installed Cap, MW	Investment of new plant, Mill. USD	Emissions, mill.Ton CO_2e
2010	12,875		30	12,875	-	30	12,875	-	30
2011	12,988	90	30	12,875	-	28	13,560	548	31
2012	14,008	816	32	13,070	156	31	15,353	1,434	36
2013	14,008	-	32	13,070	-	30	16,993	1,312	39
2014	14,008	-	32	13,569	399	31	18,534	1,233	43
2015	15,756	1,398	37	14,474	725	34	19,974	1,152	46
2016	18,094	1,870	42	15,522	838	36	21,519	1,236	50
2017	20,183	1,671	47	16,735	970	39	23,518	1,599	54
2018	21,481	1,038	50	18,668	1,546	43	25,771	1,803	60
2019	23,544	1,650	55	20,340	1,337	47	28,034	1,810	65
2020	25,414	1,496	59	21,832	1,194	51	30,458	1,940	71
2021	26,252	670	61	22,480	518	52	33,657	2,559	78
2022	27,864	1,290	65	23,805	1,060	55	37,278	2,897	86
2023	29,313	1,159	68	25,021	973	58	40,979	2,961	95
2024	31,089	1,421	72	26,484	1,171	61	44,683	2,963	104
2025	31,604	412	73	26,874	312	62	49,011	3,463	114
2026	33,539	1,548	78	28,478	1,283	66	53,584	3,658	124
2027	35,756	1,773	83	30,303	1,460	70	58,711	4,102	136
2028	36,700	755	85	30,982	543	72	63,680	3,975	148
2029	37,644	755	87	31,690	567	73	69,801	4,896	162
2030	37,644	-	87	31,690	-	73	76,020	4,976	176

Renewable energy (e.g., geothermal, hydro, biomass-based PP, MSW-based PP, etc.)

Table 5.8 presents the installed capacity and the required investment for renewable power plants BAU, CLIMATE 1 and CLIMATE 2 scenarios. The installed capacity of renewable power plants under the CLIMATE 1 and 2 scenarios is higher than that under the BAU scenario. Conventional renewables such as hydropower and geothermal power plants under the two CLIMATE scenarios are not much different from the BAU due to geographical limitation of resource availability with respect to demand center. For example, although the water resources available for power is relatively high (up to 75 GW), many of the resource locations (i.e., 25 GW in Papua) do not match with the location of demand center (i.e., Jawa, Sumatera). Similar situations also occur with regard to geothermal resources (26 GW). The significant difference between the two CLIMATE scenarios and BAU is that other renewables such solar power, wind, biomass based power plants are utilized. However, these plants are still very small compared to the total required power plant capacity and therefore their contribution towards reducing GHG emissions is not significant. Further deployment of these types of power plants are limited because such technologies are much more expensive than conventional power plants. Further development and utilization of wind power is limited because wind resources in Indonesia are not sufficient (i.e., low speed winds).

Table 5.8 The installed capacity and the required investment for renewable power plants under the BAU, CLIMATE 1 and CLIMATE 2 scenarios

Year	BAU						CLIMATE 1						CLIMATE 2					
	Installed Cap, MW			Investment, Mill. USD			Installed Cap, MW			Investment, Mill. USD			Installed Cap, MW			Investment, Mill. USD		
	Hydro	Geothermal	Other renew	Hydro	Geothermal	Other renew	Hydro	Geothermal	Other renew	Hydro	Geothermal	Other renew	Hydro	Geothermal	Other renew	Hydro	Geothermal	Other renew
2010	3,745	1,093	145				3,745	1,093	145				3,745	1,093	145			
2011	3,983	1,370	154	476	831	24	3,745	1,093	145				4,332	1,695	360	1,173	1,806	428
2012	4,243	2,114	169	520	2,232	30	4,368	2,333	456	1,247	3,719	623	4,877	2,460	458	1,091	2,294	218
2013	4,270	3,009	175	54	2,685	13	4,434	3,127	620	132	2,384	302	5,229	3,221	633	703	2,284	337
2014	5,307	3,819	176	2,074	2,430	7	5,367	4,000	769	1,865	2,617	249	6,077	4,051	794	1,696	2,490	279
2015	5,382	3,875	185	150	168	49	5,702	4,359	919	671	1,077	290	6,513	4,776	1,036	873	2,176	394
2016	6,167	4,087	194	1,570	636	51	6,492	4,722	1,083	1,580	1,088	315	7,619	4,944	1,252	2,211	502	395
2017	7,139	4,783	199	1,944	2,088	39	7,338	5,278	1,227	1,691	1,669	254	8,661	5,753	1,392	2,084	2,428	320
2018	8,067	5,650	217	1,856	2,601	83	8,132	5,940	1,431	1,589	1,986	417	9,303	6,271	1,604	1,283	1,553	455
2019	8,146	5,998	284	159	1,044	164	8,198	6,496	1,586	132	1,670	293	9,543	6,785	1,768	482	1,542	408
2020	8,211	6,060	306	128	187	83	8,313	7,053	1,769	230	1,671	327	9,750	7,333	1,927	413	1,644	344
2021	8,318	6,158	344	216	293	121	8,511	7,354	1,928	396	903	349	10,097	7,529	2,082	694	588	454
2022	8,335	6,192	365	34	103	76	8,647	7,630	2,108	272	826	364	10,247	7,807	2,288	299	835	457
2023	8,338	6,253	381	5	184	59	8,785	7,729	2,155	276	297	113	10,458	8,004	2,355	423	590	206
2024	8,479	6,359	402	282	317	97	9,029	7,705	2,319	487	-	355	10,650	8,219	2,553	383	646	469
2025	8,479	6,475	422	1	348	66	9,177	7,866	2,478	296	483	341	10,737	8,463	2,728	174	733	461
2026	8,553	6,540	442	147	195	97	9,255	7,974	2,549	158	325	149	10,854	8,518	2,792	234	166	228
2027	8,618	6,601	463	131	183	72	9,480	8,159	2,741	448	554	395	10,934	8,687	2,996	159	505	503
2028	8,927	6,745	495	618	431	101	9,546	8,206	2,902	133	142	363	11,152	8,889	3,181	437	607	527
2029	9,087	6,923	510	319	535	51	9,835	8,469	2,926	578	789	61	11,457	9,342	3,228	610	1,358	259
2030	9,171	7,055	534	169	395	69	10,091	8,706	3,119	512	710	411	11,651	9,550	3,438	388	625	620

Increasing efficiency on the energy demand side

Improvements in energy efficiency will be approximately 17% in 2020, 20% in 2025 and 23.8% in 2030. The efficiency potential in power generation is approximately 18%, whereby the efficiency potential on the demand side (i.e., household, commercial and industry) will reach 11% in 2020, 13% in 2025 and 16% in 2030. The detailed energy efficiency of each sector from 2020-2030 is presented in Table 5.9.

Table 5.9 Energy efficiency improvements by sector, 2020-2030

Key Sources of Activity	2010 - 2025									
	CLIMATE 1					CLIMATE 2				
	Efficiency, BOE %	Efficiency	Investment Cost, Million USD	Cost Saving, Million USD	Reduction Potential, Ton CO_2e	Efficiency, BOE	% Efficiency	Investment Cost, Million USD	Cost Saving, Million USD	Reduction, Ton CO_2e
Transportation	50,946,486	1%	16	3,645	116	84,727,097	1%	21	6,062	179
Industry	1,546,393,912	17%	115	110,644	22	1,923,871,786	22%	150	137,653	23
Households (w/o biomass)	100,916,073	6%	10	267	14	100,916,073	6%	10	7,221	26
Commercial	86,618,531	11%	23	230	25	106,718,845	15%	30	7,636	49
ACM	-					-				
Total	1,784,875,002	10%		114,787	177	2,216,233,802				277

"

5.2 Industry Sector

5.2.1 Policies Framework

The major GHG emissions generated from industrial processes are CO_2, methane (CH_4), nitrous oxide (N_2O) and perfluorocarbons (PFCs) in the form of CF_4 and C_2F_6; CO_2 emissions account for the vast majority, representing 93% of the total GHG emissions from industrial processes. However, current Indonesian regulations and policies do not directly control CO_2 and other GHG emissions from industrial processes.

In terms of legal aspect, these gases are still allowable under Indonesian regulations. Refer to the Decree of the State Minister of Environment/Kep. MENLH No. 129 of 2003 concerning standard quality of emissions for industrial processes; the requirement for stationary emissions sources form the industrial processes are opacity, hydrogen sulfide (H_2S) and other hydrocarbon gases, which does not cover the CO_2 or other GHG emissions. There is no specific threshold value for these types of emissions from the industrial sector.

5.2.2 Emissions Projections and Mitigation Measures

The total number of medium- and large-scale industries of varying types in Indonesia is more than 20,000. However, not all of the GHG emissions from those industries are covered in the SNC. The SNC only includes GHG emissions specifically associated with industrial processes and excludes emissions from energy consumption in industrial activities (which are already covered in the energy sector). The types of industrial processes covered in the SNC are industries that have the potential to generate GHGs, including mineral production processes (e.g., cement, lime, carbonate products), chemical production processes (e.g., ammonia, nitric acid, caprolactam), and metal production processes (e.g., iron/steel production and aluminum smelter), as covered in the 2006 IPCC Guidelines.

The methodology of GHG emissions projections for industrial processes is principally similar to other sectors, as emissions are based on projected activity data. The projections used simple econometric extrapolation techniques taking into consideration the historical trends. Activity data projections are based on projection models, which use GDP growth of the industrial sector as the growth driver. Although the average national GDP growth from 2000-2005 was only 4.7% per year, the GDP growth from the industrial sector was still high at 9.3% per annum. Considering the development that has occurred in the past five years, future GDP from the industrial sector is projected to grow at a slower rate of 6.4% per year. Future GHG emissions generated from the industrial sector are estimated to increase, consistent with the projected GDP growth of the industrial sector at 6.4% per year.

The industrial sector will reduce the rate of emissions from the BAU scenario by increasing the efficiency in production processes, introduction of new technologies, or by changing the raw materials (i.e., using waste as an alternative material in the cement industry). The emissions reductions can also be achieved through the clean development mechanism (CDM) scheme and private sector participation. Public funding is still needed for the dissemination of programs related to CO_2 emissions reductions in industrial processes.

In the analysis of future emissions from the industrial sector, two scenarios have been established by assuming that emissions reductions are carried out by the private sector through the CDM scheme and supported by government dissemination programs and other international funds/grants. Table 5.10 presents the projected emissions generated by the industrial sector from 2010-2025 under BAU and the two alternative scenarios.

Table 5.10 Projected emissions from the industrial sector under BAU and mitigation scenarios (Ggram CO_2e)

Scenario	2010	2015	2020	2025
BAU	52,850	57,296	62,117	67,343
Private scenario through CDM	49,438	52,422	56,754	61,493
Reduction Potential	3,412	4,875	5,362	5,850
% Reduction	6.5%	8.5%	8.6%	8.7%
Private scenario through CDM with support from the government through dissemination program and other international funds	46,152	49,136	53,469	58,207
Reduction Potential	6,698	8,160	8,648	9,135
% Reduction	12.7%	14.2%	13.9%	13.6%

The potential for GHG emissions reductions are estimated to occur through the following processes (i) process improvement; (ii) operation system improvement; (iii) technology change; (iv) raw material substitution; and (v) dissemination/promotion program.

5.3 Foresty Sector

5.3.1 Policy Framework

Mitigation of climate change is one of the long-term national forestry plans for the period from 2010-2029 (MoF, 2008). Five key policies that support mitigation of climate change in the forestry sector have been issued, as stated in Forestry Strategic Plan for 2005-2009 through Ministerial Decree No. P.04/Menhut-II/2005 dated on 14 February 2005. These include the following:

1. **Combating illegal logging and its associated trade**, through (i) securing forest areas and (ii) controlling forest product administration;

2. **Revitalization of the forestry sector, particularly the forestry industries**, through (i) natural production forest management under non-concessionaire license; (ii) development of plantation forest; (iii) management (utilization) of primary production forest; and (iv) restructuring of the primary forestry industry;

3. **Conservation and rehabilitation of forest resources**, through (i) plantation seeds development, (ii) management of watershed areas; (iii) forest and land rehabilitation; (iv) self-management of forest and land rehabilitation; (v) development of national park management; (vi) management of nature preservation/sanctuary reserve/hunting park areas; (vii) controlling forest fires; (viii) management of biological diversity; (ix) management of protected forest; and (x) utilization of wildlife and plant products and environmental services;

4. **Empowering the economy of the community within and surrounding the forest area**, through (i) development of community forest and community plantation forest; (ii) development of non timber forest product (NTFP) utilization; (iii) development of buffer zone area surrounding conservation areas; and (iv) development of social forestry; and

5. **Stabilization of forest area for promoting and strengthening sustainable forest management**, through (i) inventory and mapping of forest resources; (ii) development of Information Assessment System on Forestry Development; (iii) gazettement of forest area, (iv) preparation and evaluation of the utilization and conversion of forest area; and (v) development of Forest Management Units (FMUs).

In 2009, Ministry of Forestry issued eight policy strategies for forestry sector through Ministrial Decree No.70/Menhut-II/2009 dated 7 December 2009, as the basic for forestry activities in 2009-2014. Mitigation and adaptation of climate change for forestry sector are clearly stated as one of the strategies that include:

1. Area establishment,
2. Forest rehabilitation and improvement the carrying capacity of watershed area,
3. Forest protection and forest fire control

4. Conservation of biodiversity
5. Revitalization of forest utilization and forestry industries,
6. Empowerment of forest community and forest industries,
7. Mitigation and adaptation of climate change for forestry sector,
8. Strengthening the forestry institutions.

Consistent with the above programs, targets for the long-term national forestry strategic plans include: (1) Confirmation of 60 million hectares of forest area by 2014; (2) Rehabilitation and establishment of new plantations with the following targets for 2012: industrial forest plantations (7.2 million ha), community plantation forest (5.4 million ha), community forest (4 million ha) and social forestry (2 million ha); (3) Forest protection and natural resources conservation (120.3 million ha); (4) Development of economic and social functions; (5) Establishment of institutions; and (6) Research and development.

The legal and policy framework already exists through which Indonesia could undergo a significant reduction in future carbon emissions. Key pieces of legislation include:

- Government Regulation (PP) No. 35/1995 on reforestation fund;
- Government Regulation (PP) No. 34/2002 on land use, forest management planning, forest and forest land use;
- Government Regulation (PP) No. 45/2004 on forest protection;
- Government Regulation (PP) No. 6/2006 on forest management and utilization;
- Government Regulation (PP) No. 6/2007 on forest planning management and forest utilization;
- Government Regulation (PP) No. 10/2010 on procedure for exchanging forest utilization and forest function
- Government Regulation (PP) No. 11/2010 on rules on the optimizing the use of abandoned land
- Presidential Instruction (Inpres) No. 4/2005 on combating illegal logging;
- Presidential Instruction (Inpres) No. 2/2007 on rehabilitation of the ex-Mega Rice Project in Central Kalimantan;
- Minister of Forestry Regulation (Permenhut) No. 14 /2004 on Afforestation and Reforestation (AR) CDM
- Minister of Forestry Regulation (Permenhut) No. 1/2004 on social forestry.
- Minister of Forestry Regulation (Permenhut) No 68/Menhut-II/2008 on the implementation of REDD demonstration activities.
- Minister of Forestry Regulation (Permenhut) No. 36/Menhut-II/2009 on procedure for getting permit for implementing carbon sequestration, carbon conservation on production forest and protection forest.
- Minister of Forestry Regulation (Permenhut) No 30/Menhut-II/2009 on procedure for implementing REDD activities
- Economic and Finance Ministerial Decree (Kepmen Ekuin) No. 14/2001 on Integrated Water Resources;

- Forest Ministerial Decree (Kepmenhut) No. 159/2004 on restoration of degraded ecosystem in productive forest areas;

5.3.2 Emissions Projections and Mitigation Measures

The forestry sector developed emissions and carbon sequestration projections based on historical data. Under the BAU scenario, the future deforestation rate is assumed to be constant at a rate of 1.1 million ha per year (see Figure 5.9). Figure 5.9 shows that the rate of deforestation from 2000-2006 has decreased compared to the previous period. In the analysis, this trend was not taken into account because of the potentially increasing threat of the conversion of forest area to non-forest area due to the formation of new districts in the future. Similarly, the future capacity to establish forest depends on rehabilitation programs (reforestation and afforestation), community forestry, community forest plantation, etc. and are assumed to be the same as historical rate. From 2000 and 2006 satellite data, it was suggested that the rate of forest establishment between 1996 and 2006 was about 198 thousand ha per year (MoF, 2009).

Using the above assumption, under the BAU scenario, the emissions from biomass removal due to deforestation was projected to be constant at a rate of about 0.898 Gt CO2 per year. The rate of sequestration is assumed to increase from 0.505 Gt CO2 per year in 2005 to 0.753 Gt CO2 in 2020. Sequestration of carbon occurs as a result of regeneration of secondary forests, land rehabilitation (i.e., afforestation and reforestation), and regrowth of woody vegetation (i.e., perennial crops and shrubs). Based on various studies, the mean annual growth rate of secondary forest is assumed to be approximately 5.32 tCO2/ha, forest plantation is 36.7 t CO2/ha, and other perennial crops/shrubs is 13.5 tCO2/ha.

Under the BAU scenario, this sector will continue as net emitter. The Government of Indonesia, as part of its non-binding emissions reduction target, will increase the rate of planting from 198 thousand hectare per year to 500 thousand ha per year, which is referred to as mitigation scenario "1." In its Strategic Plan, the forestry sector set up a progressive target with a rate of planting of between 1.6 and 2.2 Mha per year (Table 5.11), which is called as Mitigation Scenario 2. With this rate of planting this sector will become net sinker after 2015. After 2015, the rate of carbon sequestration is projected to be greater than the rate of emissions (Figure 5.9).

Table 5.11 Rate of planting in the Strategic Plan of the Ministry of Forestry (MoF, 2009)

Year	Forest Plantation	Community forest	Forest restoration	Watershed rehabilitation	Partnership forest	Total
2010	450	500	300	300	50	1600
2011	550	500	350	300	50	1750
2012	500	500	450	300	50	1800
2013	600	500	650	350	50	2150
2014	550	500	750	350	50	2200
2015	450	500	300	300	50	1600
2016	550	500	350	300	50	1750
2017	500	500	450	300	50	1800
2018	600	500	650	350	50	2150
2019	550	500	750	350	50	2200
2020	500	500	750	350	50	2150
Total	5800	5500	5750	3550	550	21150
Source of Fund	**Private**	**Government**	**Private and International**	**Private and International**	**CSR and Community**	

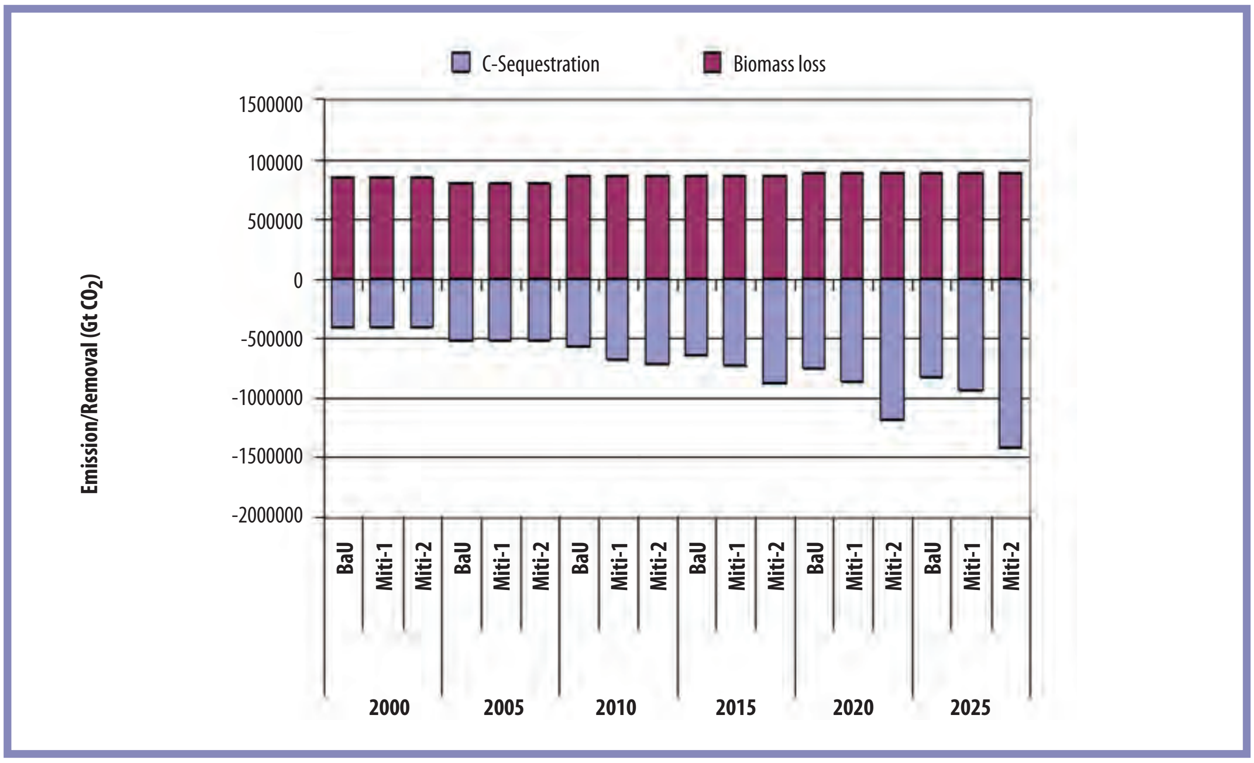


Figure 5.9 Rate of carbon sequestration and emissions under the BAU scenario and the two mitigation scenarios (Ministry of Forestry)

The progressive target in the Strategic Plan will be hard to meet without international support (see Table 5.12). Government of Indonesia has identified potential funding sources that can be used to achieve such targets, namely the REDD Fund, private investment, grants through bilateral and multilateral channels such as Overseas Development Assistance (ODA), Adaptation Fund under the Kyoto Protocol, Global Forest Fund (GFF), and Debt for Nature Swaps (DNS). Indonesia applied for debt reduction under the Tropical Forest Conservation Act of the USA and used the fund for forest conservation activities.

In addition, the previously (albeit briefly) mentioned UN Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation (REDD) also has high potential for providing additional support to Indonesia and several countries have made already made commitments [to support Indonesia]. Both REDD and the Forest Carbon Partnership Facility (FCPF) have made commitments to support Indonesia in developing an effective and accountable framework for REDD, together with Australia, the United Kingdom, Germany, Japan and Korea. Table 5.12 presents some of the international support for Indonesia related to implementing forestry mitigation projects.

Table 5. 12 Program support from international agencies for forestry mitigation projects in Indonesia

Title	Cooperation to Support Forest Governance and Multi-stakeholder Forestry Programme
Duration	2007-2010
Objective	1. Support governance reforms to reduce and eventually eliminate illegal logging and its associated timber trade, with a particular focus on support for negotiation and implementation of the EU-GoI FLEGT VPA and other international arrangements; 2. Through a multi-stakeholder approach, help build the capacity of central and local government and civil society, support partnerships between government and civil society, promote policy analysis and development and support poverty reduction through more equitable and sustainable management of natural resources, with a particular focus on the rights and opportunities through community forestry for disadvantaged and women's groups; 3. Explore the opportunities for governance reforms that are necessary for REDD.
Title	**Financial Cooperation for Climate Change and REDD Issue; Project title: Forestry-Climate Change Project in Central and East Kalimantan (FCCP)**
Duration	7 years, started 2009
Objective	To support Indonesia with the reduction of GHG emissions from deforestation and forest degradation. Specific objectives: 1. To support policy priorities of the Ministry of Forestry in REDD; and 2. To support the implementation of mechanisms related to avoiding deforestation by development of pilot projects in Indonesia with the involvement of local communities in sustainable forest management.
Title	**Technical Cooperation (TC) Supporting implementation of the Ministry of Forestry's Strategic Plan**
Duration	3 years, started mid-2008
Objective	To implement the Strategic Plan which is integrated and synergized with other sector planning – specifically,, provincial and districts programs

Title	Technical Cooperation Forestry Program in Implementing The Heart of Borneo (HoB) Initiative (Malaysia, Indonesia and Brunei Darussalam)
Duration	3 years, started mid-2008
Objective	1. To establish trilateral, national and local (states, provincial and district) institutional arrangement to support the implementation of the HoB Initiative; 2. To develop mechanisms, including inter-alia action plans at all levels, on the implementation of HoB programs; and 3. To strengthen the capacity of stakeholders related to the implementation of HoB programs.
Title	**Kalimantan Forests and Climate Partnership**
Duration	2007-2012
Objective	The goal of the program is to support the GOI's efforts to reduce GHG emissions associated with deforestation in Indonesia, through actions to reduce rates of deforestation, support reforestation and promote sustainable forest management and deliver improvements to rural livelihoods and environmental benefits.
Title	**The United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries** **UN-REDD Programme)**
Duration	2009-2011
Objective	A Food and Agriculture Organization (FAO), UN Development Programme (UNDP) and UN Environment Programme (UNEP) collaboration, UN-REDD in Indonesia aims to: 1. Strengthen multi-stakeholder participation and consensus at the national level; 2. Successfully demonstrate the establishment of the Reference Emission Level (REL), Monitoring, Reporting and Verification (MRV) and fair payment systems based on the national REDD architecture; and 3. Build capacity to implement REDD at decentralized levels through demonstration activities and other support.
Title	**Korea-Indonesia Joint Program on Adaptation and Mitigation of Climate Change in Forestry through A/R CDM and other Related Mechanisms**
Duration	2008-2012
Objective	1. Analyze REDD applications and acquire a framework of carbon credits by preventing forest conversion as a post-2012 preventive measure; 2. Implement capacity building programs, including expert exchange and training courses; and 3. Acquire cost-effective potential A/R CDM sites and establish a foundation for carbon credits in preparation of post-2012 emissions commitments.

Source: Ministry of Forestry, Republic of Indonesia

5.3.3 Mitigation Costs

Studies on forestry mitigation in Indonesia have been conducted since early 1990s (e.g., Directorate for Nature and Management [DNM] Norway and Ministry of State of Environment [MSE] Indonesia, 1993; Adi et al., 1999; Boer et al., 1999; Boer, 2000; Fuad, 2000; Boer, 2001; Boer et al., 2001). In terms of cost for forestry mitigation, the results of the studies varied considerably (Table 5.13). A recent study conducted by DNPI (2009) suggested that the average cost for reducing emissions in the forestry sector was approximately 9 USD/tCO2 or about 2.5 USD/tC, while the MoF (2007) estimate was between 10 and 23 USD/tC.

Table 5.13 Mitigation potential and cost for forestry sector

Mitigation	Mitigation potential (tC/ha)	Life cycle cost (USD/tC)
Conservation and forest management		
Forest Protection	55-220	1.18
Reduced Impact Logging	49	0.07
Enrichment planting	70	0.25
Sink enhancement		
Reforestation without rotation/harvesting		
- Fast growing species	40-101	0.85-22.5
- Slow growing species	94-336	0.48-2.34
Reforestation with rotation/harvesting		
- Short rotation	56-122	3.87-33.20
- Long rotation	134-334	1.04-5.70
Agroforestry	94	4.44
Fossil fuel substitution		
Bioelectricity	50-185	20.81

Source: Based on various sources, including Adi et al., 1999; Boer et al., 1999; Fuad, 2000; Boer, 2001; and MoF, 2007.

5.4 Peatland

5.4.1 Policy Framework

To support the implementation of programs related to reduce emissions from land and forest fires, forest conversion and peat land from agriculture plantation, the Government of Indonesia has issued a number legal instruments. Relevant legal instruments designed to control fire include the following:

- Ministry of Agriculture Regulation No. 14/Permentan/PL.110/2/2009 on the Guidance for the Utilization of Peat Land for Palm Oil;
- PP No. 4/2001, forbids all forest and land fires;
- Ministry of Forestry Decree Kepmen No. 260/Kep-II/1995 on Guidelines for Prevention and Control of Forest Fire, supplemented with the implementation guidelines;
- Director General of Forest Protection and Nature Conservation (PHPA) Decree No. 243/Kpts/DJ.VI/1995 on Technical Guidelines for Forest Fire Prevention and Control in concession areas and other land use;
- Director General of Estate Crops Decree No. 38/KB.110/DJ.BUN/05.95 on Technical Guidelines for Land Clearance without Burning to Develop Plantations;

- While strict legal penalties for persons causing fire are stipulated in UU No. 41/1999, article 78 clauses 3, 4 and 11, are as follows :
  - o Intentionally setting fire to forest: Prison sentence maximum of 15 years and a maximum fine of 5 billion Indonesian Rupee (IDR)
  - o Negligence leading to forest fire: Prison sentence maximum of 5 years and a maximum fine of 1.5 billion IDR
  - o Dumping of materials which can cause forest fire: Prison sentence maximum of 3 years and a maximum fine of 1 billion IDR

- Government Regulation No. 28/1985 on Forest Protection:
  - o Article 10, point 1: burning the forest on purpose will be fined with a maximum of 10 years in prison or 100 million IDR
  - o Article 18, point 3b: burning of forest as a result of carelessness will be fined a maximum of 1 year in prison or 10 million IDR

5.4.2 Emissions Projections

Under the BAU scenario, it was assumed that all peat land under convertible production forest (HPK) irrespective of depth will be released and used for non-forestry activities (APL). Peat land in HPK will be released for APL within the next 15 years and used for agriculture activities (BAPPENAS, 2010). The emissions from peat fire are assumed to be the same as the average rate of emissions from 2000-2006 estimated by van der Werf et al. (2008). Based on this assumption, the rate of emissions from peat land in 2020 might reach 1.4 GtCO2, about approximately four times the 2000 peat emissions.

5.5 Agriculture Sector

5.5.1 Policy Framework

There is no specific policy in the agriculture sector for climate change mitigation. However, a number of mitigation programs are already in place. The key mitigation programs include (MoA, 2007; Las *et al.*, 2008; Bappenas, 2010):

1. Implementation of no-burning technology for land clearing and land preparation, in food crop, horticulture, and plantation sub-sectors;
2. Development of a Fire Early Warning System to reduce the risk of fire during extreme drought years, particularly in peat areas;
3. Introduction of low methane emitting rice varieties. Currently, there are four varieties used that have low methane emissions – Ciherang, Cisantana, Tukad Belian and Way Apo Buru.
4. Introduction of low methane emitting technologies, such as the use of agriculture waste for bio-energy and composting;
5. Development and application of organic fertilizer and bio-pesticides

6. Introduction of biogas technology and improved feed to reduce methane emissions from the livestock. A number of related activities that have been implemented are the 'Batamas' program, mixed-farming and mini animal feed industries;
7. Optimation of existing agricultural lands by increasing productivity and cropping index through technology innovation support as new improved varieties
8. Expansion of agriculture areas in unproductive land such as grassland and abandoned land particularly to mineral soils either in upland or wet lands
9. Rehabilitation, reclamation and revitalization of abandoned peat lands, and management of peat land for sustainable agriculture,
10. Research and development on low emission technology and MRV in agriculture sector

In the framework of green economy development program, Indonesia is developing carbon efficient farming (ICEF) by organizing farmers in villages or sub-districts. ICEF is an integrated of crop-livestock with low emission, energy efficient and high economic added values. ICEF optimally utilizes all the carbon from crop production and waste or by products from both the crop and livestock.

5.5.2 Emissions Projections and Mitigation Measures

The main sources of CH4 emissions from the agriculture sector are rice fields and livestock. Projections of emissions under these two sub-sectors were developed using a number of assumptions to model the impacts of differnet policy options. The assumptions were developed by considering historical conditions and a trend of population growth. For rice, two baseline scenarios were developed:

1. **BAU1**. This baseline adopted the assumption that all irrigated rice fields are continuously flooded and applied inorganic fertilizers to Cisadane rice variety. The area of the irrigated rice in Java will not change due to the adoption of regulations related to sustainable agriculture land; outside Java, the land area devoted to irrigated rice will increase at a rate of 50 thousand ha per year. The cropping index is assumed to be 2.4 if the source of irrigation came from a reservoir and 1.4 if source of irrigation is not from reservoir.

2. **BAU2**: Similar to BAU1, but the rice paddy area in Java is assumed to be converted to non-rice paddy area at a rate of about 50 thousand ha per year; outside Java, rice paddy area will increase at a rate of about 150 thousand ha per year.

To reduce emissions from the rate under BAU, six mitigation scenarios were proposed, as shown in Table 5.14 (S1-S6). In the mitigation scenarios, the rice variety used was changed from Cisadane to IR64. By 2030, the total rice paddy area that applied mitigation technologies is less than 30% - specifically, 21% for S1, 5% for S2, 15% for S3, 14% for S4, 6% for S5 and 1.6% for S6. Using these assumptions, it was found that total methane emissions in 2030 under BAU1 and BAU2 would be about 38,804 and 42,434 Gg CO_2e, respectively. The most effective mitigation scenario would be the adoption of less methane-emitting varieties (Figure 5.10). Adoption of new less methane emitting varieties would reduce the rate of methane emissions from BAU by approximately 20%.

Table 5.14 Mitigation scenarios for reducing methane emissions from paddy rice

Scenario	Mitigation Technology	Potential applicability (%)	Rate of the technology adoption (Percent of potential applicability area)					
			2005*	2010	2015	2020	2025	2030
S0	Flooded with inorganic fertilizer (according to Kepmentan)	100	100	100	100	100	100	100
S1	Intermittent irrigation (including SRI, PTT)	70	3	5	10	20	25	30
S2	Fertilizer supplement (ZA and urea brisket)	100	0	0	1	2	3	5
S3	Adoption of less methane emissions-varieties*	30	20	25	30	40	45	50
S4	Intermittent + fertilizer supplement (Combine S1 and S2)	70	3	5	8	10	15	20
S5	Intermittent + fertilizer supplement + varieties (Combine S1, S2 & S3)	30	3	5	8	10	15	20
S6	S5 + iron material/silica	30	0	0	1	2	4	6

Note: Total paddy rice area was assumed to be about 7.8 million ha. Potential applicability area refers to the total area applicable for the mitigation technologies. The remaining areas that do not use the mitigation technologies still use the baseline technologies. Less methane emitting varieties include Ciherang, Cisantana, Tukad Belian and Way Apo Buru (Setyanto ***et al***., 2009)

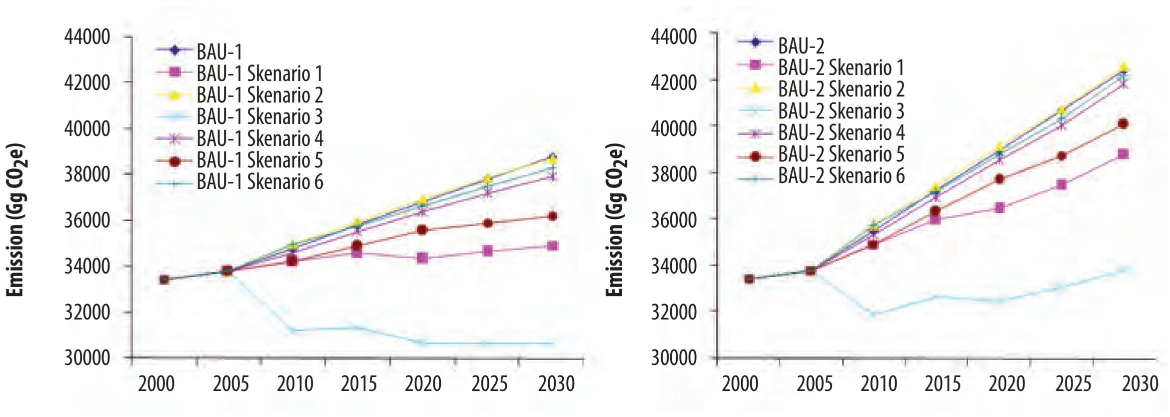


Figure 5.10 The projection of methane emissions from rice paddies under the baseline and mitigation scenarios (Setyanto et al., 2009)

The projection of emissions for livestock was consistent with the population growth projection. The annual population growth rate of the livestock was assumed to follow the historical population growth rate, whereas beef cattle and dairy cattle increase at an annual rate of 5%, broiler and layer 3%, buffalo, sheep, goat, pig and local chicken 2%, and horse and duck 1%. With these growth rates, the domestic demand for these animals will not be fully met, implying that Indonesia may still need to import meat and milk.

Mitigation technologies that have been identified for this sub-sector are the following:

1. **Feeding Quality Improvement**. Currently, beef and dairy cattle feeding practices are less efficient (increasing losses of feed energy in the form of methane and reduced amounts of energy stored in animal product). Utilization of low digestible feedstuff, a higher proportion of forage and low quality pasture (especially in eastern parts of Indonesia) are the main problems. Increasing conversions of feed energy to animal products will not only decrease methane emissions, but also benefit the farmer. Feed quality improvement programs of beef and dairy cattle will reduce up to 20% of methane emissions. Some possible activities for reducing methane emissions through improved feed quality are:

   a. Introduction of high quality local feed sources such as legume and high quality grass, as well as utilization of agriculture byproducts;
   b. Improvement of low quality byproducts using physical, chemical or biological pre-treatment;
   c. Increasing concentrate to forage ratio; and
   d. Increasing animal productivity by intensity of production (feeding as required). The equal amount of animal product will be produced by less animal number.

2. **Supplementation**. Supplementation of minerals in the form of feed supplement blocks (FBS) has been tested on a limited scale by smallholder farmers. One study reported that mineral supplements increased animal productivity, reducing methane formation by up to 15% (Suryahadi et al., 2007). Mineral supplementation programs have a lot of advantages due to their simplicity of application and high success rate (less risk of failure).

3. **Long-term Breeding Program**. Improvement of animal breeding could mitigate up to 10% of methane emissions from livestock. This improvement could be achieved through appropriate long-term breeding programs. The animals will be bred for adaptation to climate, higher productivity and less methanogenic bacteria/methane production. A potential breeding program would need high investment and would yield long-term return rates, thus likely requiring government support.

4. **Bio-energy**. Utilization of animal sewage as bio-energy is a clear option because of its relevance to national government programs. Currently, the Indonesian government is trying to incentivize the deployment of renewable and environmentally-friendly energy resources. Bio-energy from animal sewage could reduce methane emissions up to 80%

compared to untreated sewage. Furthermore, a co-product of the digester used is an organic fertilizer, which could be used on crops and plants, would have high economic value. This program has disadvantages, however, because of the significant investment needs related to digester technology deployment.

With the adoption of these options (Table 5.15) the rate of methane emissions from this sub-sector would reduce slightly (Figure 5.11).

Table 5.15 Projected mitigation technology options adopted for livestock

No.	Mitigation Options	Animal population mitigation applied to*
1.	Supplementation	1% of beef cattle and 3% of dairy cattle population per year
2.	Improvement feeding practices	2% of beef cattle and 5% of dairy cattle population per year
3.	Manure management/biogas	1% of beef cattle and 1% of dairy cattle population per year
4.	Long-term breeding program	1% of dairy cattle population per year
5.	Tree legume introduction	1% of dairy cattle of population per year

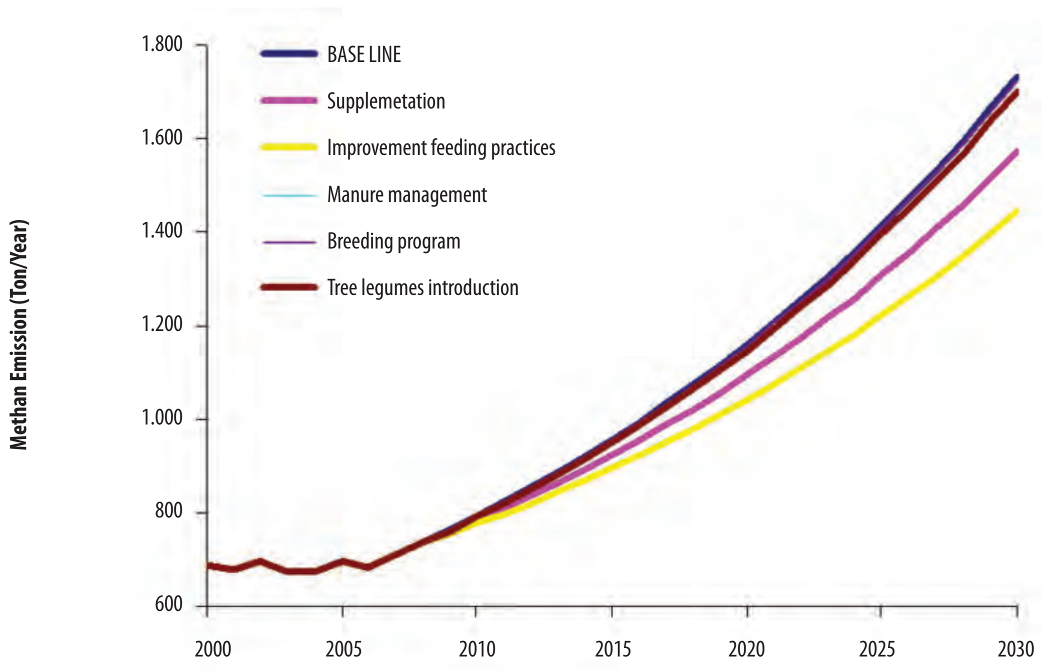


Figure 5.11 Projected methane emissions from livestock (Suryahadi et al., 2009)

5.6 Waste

Municipal solid waste (MSW) landfills are the most significant of GHG emission sources within this sector. Other major sources are industrial solid waste, domestic liquid waste and industrial liquid waste. The national generation of MSW was approximately 47.8 million tons in 2000 and increased to 48.7 million tons in 2005 (estimated from population data and waste generation factors given by Profil Nasional Program Bangun Praja from Ministry of Environment, 2004]. In urban areas of big cities, almost 60% of waste is brought to a solid waste disposal site (SWDS), while in small cities and rural areas, only 30% of waste is brought to a SWDS (Indonesian Statistical Data on Environment, BPS, 2000-2007). The major components of the solid waste brought to SWDS are organic compounds because other types of waste (i.e., plastics, metal, etc.) are generally recycled for reutilization. The SWDSs in most big cities of Indonesia are considered to be unmanaged SWDS (an open dumping system). Currently, incinerators for MSW are generally not used in Indonesia. Although several statistical data indicate that inceration is already used for eliminating MSW, the so-called 'incinerator' is actually an 'open burning' system.

The main source of industrial solid waste is from agro industries, particularly empty fruit bunches (EFBs) generated from palm oil mills. The total amount of waste in 2000 was 6.3 million tons and increased to 12.5 million tons in 2005. The amount of this waste was estimated from waste generation factor (CDM Project Surveys by EcoSecurities, 2007) and palm oil production rates (Central Bureau of Statistic Indonesia, 2007). The current practice for handling EFBs is open dumping (unmanaged) within the vicinity of the palm oil mills.

Domestic wastewater, represented by biological oxygen demand (BOD), was equal to 3 million tons BOD in 2000 and it increased to 3.2 million tons BOD in 2005. Industrial wastewater produced, expressed in terms of TOW was equal to about 23.6 million tons COD in 2000 and 23.7 million tons COD in 2005. The major contributor to industrial wastewater COD is pulp and paper industries. Production of this waste will increase in the future.

To reduce emissions from solid waste, the Government of Indonesia enacted Municipal Solid Management Law No. 18/2008. According to the Law, open dumping practices will be prohibited in the year 2013. It is expected that the Law will encourage the development of a more managed waste handling system (i.e., a sanitary landfill equipped with gas flaring or utilization systems). The GOI expects that after 2020, around 80% of the domestic liquid waste will be handled by sewerage systems.

To estimate future emissions, three scenarios have been established: (a) the BAU scenario assumes that emissions growth will follow historical trends, without any efforts or programs related to climate change mitigation; (b) emissions reductions are to be achieved through implementation of Municipal Solid Management Law No. 18/2008; and (c) further emissions reductions from the waste sector are to be achieved through the implementation of Municipal Solid Management Law No. 18/2008 combined with international funding (CDM scheme or other schemes). The projection of the BAU and the other two alternative scenarios is presented in Table 5.16.

Table 5.16 Projection of GHG emissions from waste sector under BAU and alternative scenarios (Dewi et al., 2009)

Scenario Mitigation	2010			2020			2025		
	BAU	S1	S2	BAU	S1	S2	BAU	S1	S2
Total MSW	19,691	19,199	18,706	22,198	19,423	17,204	23,562	20,028	17,672
Unmanaged Dumpsite (CPO)	11,289	10,725	10,443	13,269	10,615	9,288	14,385	10,069	8,631
Domestic WWT and Discharge	13,568	12,890	12,551	15,287	12,230	10,701	16,227	11,359	9,736
Industrial WWT and Discharge	149,818	142,327	138,582	199,477	159,581	134,647	224,411	157,088	123,426
Total Emission	**194,367**	**185,141**	**180,282**	**250,231**	**201,849**	**171,839**	**278,585**	**198,544**	**159,465**

Based on the emissions projection analysis, it was found that by 2020, the rate of emissions under mitigation scenario 1 reached 31% of the BAU emissions and that under mitigation scenario 2, it could reduce up to 48% (Figure 5.12). Net emissions under BAU in 2020 are expected to be approximately 2.95 Gt CO2 – more than double the emissions in year 2000.

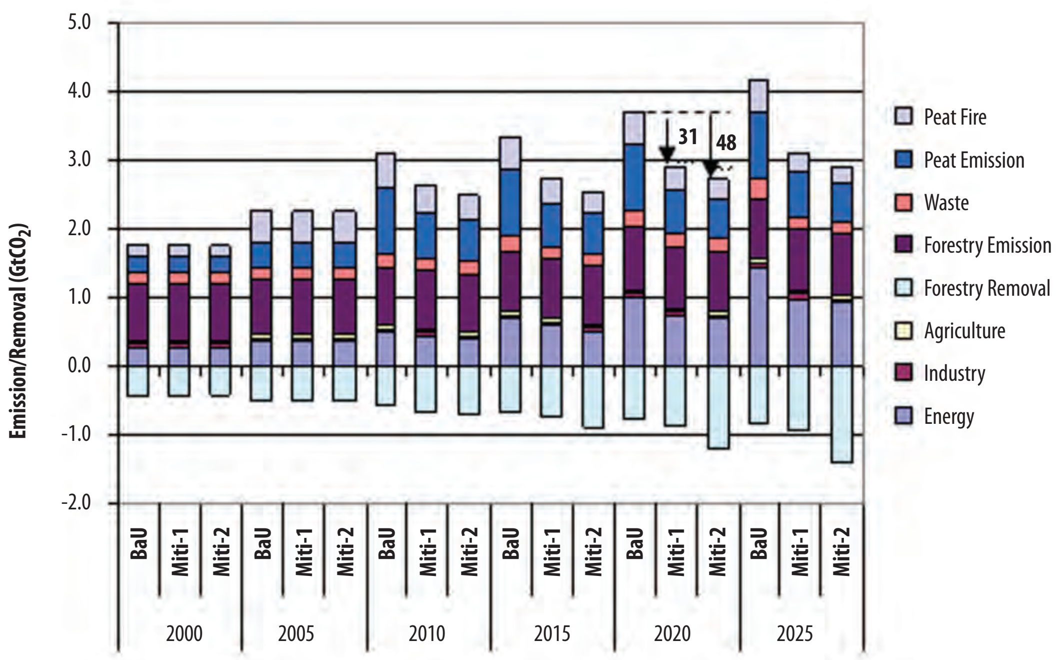


Figure 5.12 Projection of emissions of all sectors under BAU and mitigation scenarios (MoE, 2009). Note: Contribution of transportation sector to the total energy emission is approximately 20% (based on emissions data from 2000-2006).

CHAPTER VI
OTHER INFORMATION

Other information considered relevant to the achievement of the objectives of the Convention includes (i) technology transfer, (ii) Research, (iii) systematic observations, (iv) information on education, training, public awareness and capacity-building and (v) efforts to promote information sharing.

6.1 Transfer of Technology

Transfer of technologies related to climate change occurs through the implementation of CDM projects. At present, Designated National Authorities for CDM, KOMNAS MPB, has approved about 104 CDM projects. Of this, about 24 projects have been registered at the Executive Board (www.dna-cdm.menlh.go.id/id/database). Most of the proponents of the CDM projects are private companies. However, NGOs play important roles in the implementation of adapatation and mitigation activities with local communities. Based on data from the SGP-GEF UNDP program, there are about 18 NGOs working on climate change mitigation projects. This NGO work is predominantly centered in Java (Figure 6.1) and the focus of their activities is mostly on the energy and waste sectors.

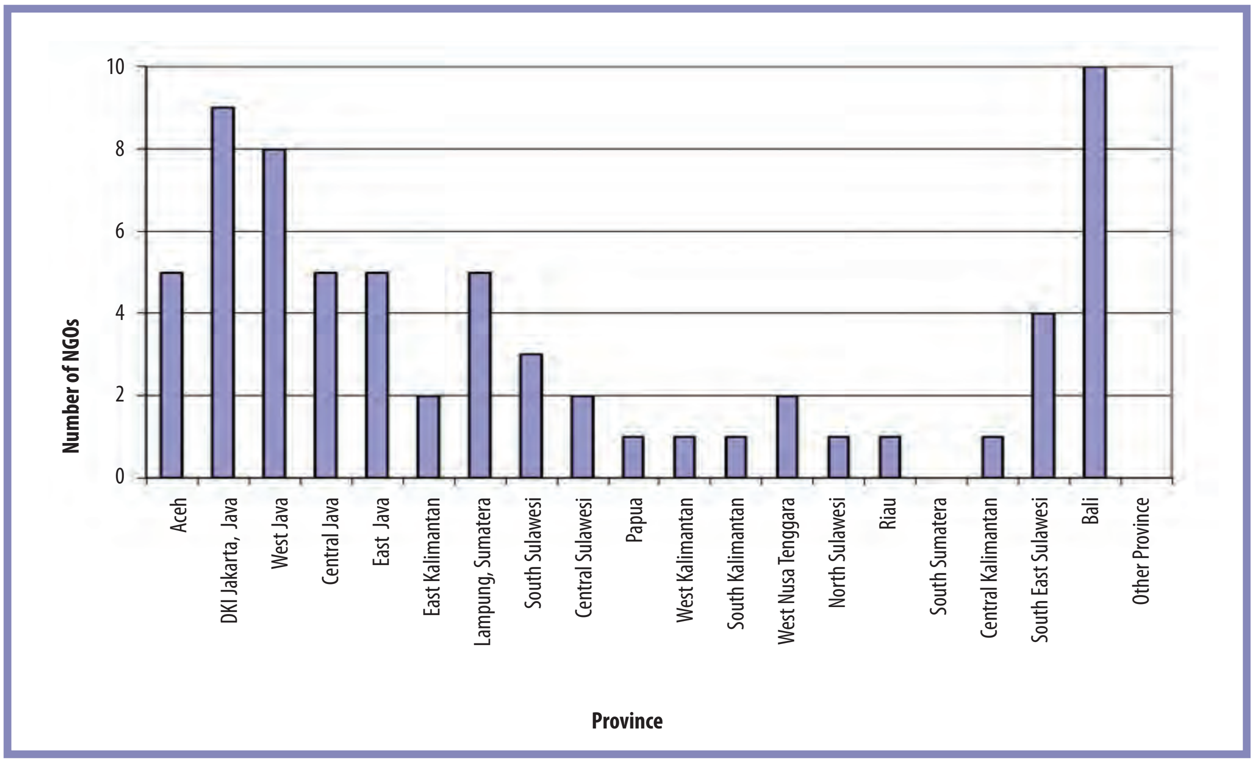


Figure 6.1 Number of NGOs working in climate change mitigation activities on energy and waste sectors (Boer *et al.*, 2008)

Several NGOs,especailly those who have technical competencies, act also as CDM or voluntary carbon project developers. NGOs or some international NGOs who have technical expertise on digester construction, in collaboration Agency for Rural Technology Development (LPTP, Lembaga Pengembangan Teknologi Pedesaan), have provided technical assistance for designing the necessary infrastructure for community. NGOs receive funds as grants from a number of development agencies. Often these funds are distributed through development aid programs and INGOs (International NGOs).

6.2 Research

Research activities related to climate are implemented by many research agencies and universities. Some international organizations based in Indonesia recently have also focused their research activities on climate change. Based on a survey conducted in 2007 of nine organizations working on climate related activities (Boer and Kartikasari, 2007), it was found that research activities conducted by the agencies was quite variable. Research activities on climate applications were mainly conducted by the Research Agency on Agro-climatology and Hydrology (BALITKILIMAT) and Bogor Agriculture University (IPB), climate early warning systems by LAPAN (National Agency for Aviation and Space) and BMKG (National Agency for Meteorology, Climatology and Geophysics), and weather modification by the Agency for Technology Assessment and Application (BPPT). Basic research on weather and climatology modeling were conducted by LAPAN, Bandung Institute of Technology (ITB), BMKG and IPB. Most NGOs have no research activities. However at present, many NGOs also conduct climate research activities and mostly the research were conducted in collaboration with universities and research agencies. At present, research activities on climate change for agriculture sector is coordinated by Indonesian Agency for Agriculture Research and Development through Indonesia Centre for Land Resources Research and Development that have four research agencies namely Agro-climate and Hydrology Research Institute (BALITKILIMAT), Agriculture Environment Research Institute (BALINGTAN), Soil Research Institute (BALITTANAH), and Swampy Land Research Institute (BALITRA).

The number of research scientists in the surveyed research agencies and the universities that hold advanced degree is about 90 people (33 PhD and 57 Master). About 29% have expertise in the area of applied meteorology or applied climatology, 23% meteorology, 16% climatology or climate modeling, 10% atmospheric chemisty of air pollution, 10% hydrology or hydrometeorology, the remaining are atmospheric physics/radars atmosphere, GIS/Remote sensing, microclimatology, geography, astronomy and meteorology instrumentation. The scientists with expertise in applied climatology concentrates in IPB and BALITKLIMAT, while those with expertise in climatology/meteorology concentrate in ITB, BPPT, LAPAN and BMG (Boer and Kartikasari, 2007). However, recently some of the agencies have expanded their research activities to climate application. For example, BMKG has established a new agency called the Research Centre on Climate Change and Air Quality. Some universities have also established new climate research centers.

To accelerate the development of mitigation and adaptation technologies, in 2008 the Government of Indonesia under the coordination of the Ministry of Agriculture has established the Research Consortium on Climate Variability and Climate Change (especially for Agriculture Sector). This consortium plays role in (i) coordinating each sector's adaptation research resources to more effectively support climate change decision-making, including the brokering of research partnerships and providing a vehicle to commission new integrated research; (ii) Synergizing research programs and activities on climate change and establishing a road map in mitigating and adapting to climate change, (iii) building the capacity of the Indonesia research community to generate information relevant to decision-makers; (iv) establishing an interface between researchers and decision-makers; (v) promoting coordinated programmes of work on impacts and adaptation across Indonesia, working in collaboration with stakeholders and other researchers in national, regional and sectoral contexts, (vi) synthesizing policy and developing sectoral roadmap for addressing climate change for 2010-2050, (vii) delivering the information to support climate change adaptation decision-making at the national, regional and local levels through coordination, integration, synthesis and communication of research.

The consortium conducts research and development activities on inventories, mitigation and adaptation, which include the following: (i) development of GHG emission and removal factors and methods for improving activity data, (ii) identification and development of mitigation technologies potential for carbon trading as well as the development of baseline and monitoring methodologies for the technologies as required by the CDM Executive Board, and (iii) conducting policy research on maintaining food crop self sufficiency under changing demography, socio-economic, land use and climate (e.g. mapping vulnerable areas to climate change, strategies for coping with the climate changes etc). The Ministry of Agriculture for the fiscal year of 2008/2009 and 2009/2010 have allocated research funds from the National Budget for the consortium by about 0.4 Million USD. The Ministry of Research and Technology through BPPT for the fiscal year of 2008/09 has also allocated about 1.5 Million USD to implement research activities on climate change. There are many climate change research activities implemented by other research agencies using national budget. However the data and information on this is not well documented.

6.3 Systematic Observations

Systematic observation of the climate in Indonesia is coordinated by the National Agency for Meteorology, Climatology and Geophysics (BMKG). Rainfall Observation Networks exist since Dutch Colonial Era. After independence, more rainfall stations were installed, however, the efforts are still far from enough to have a representative number of stations across the country. The total number of rainfall observation network (rain gauges) is about 5,000 gauges. Most of the gauges are located in Java and then followed in Sumatra, Sulawesi, Maluku, Kalimantan and Papua (Table 6.1). The ideal number of rain gauges to meet the WMO standard for Indonesia is about 20,000 gauges (Sribimawati, 1999). In addition to the rain gauges stations, BMKG also installed a number of automatic weather stations (AWS) and Radar in a number of places particularly in areas prone to weather/climate hazards. In collaboration with WMO, BMKG has also established one Global Atmospheric Watch (GAW) in Bukittinggi, West Sumatra. With the presence of the GAW, Indonesia becomes part of the global atmospheric observation under World Weather Watch.

Table 6.1 Rain gauges density in Indonesia

No.	Island	Rain gauge density per 100 km^2
1	Java	11.6
2	Sumatra	0.87
3	Sulawesi	0.67
4	Maluku	0.46
5	Kalimantan	0.18
6	Papua	0.05
7	Other island	0.67-1.14

Source: Sribimawati et al. (1999)

Indonesia has installed a number of instruments to monitor sea level (Figure 6.2). The existing Indonesia Sea Level Monitoring Network consists of 65 operational stations. More stations will be installed through an ongoing program called the establishment of Indonesia Tsunami Early Warning System (IndTEWS). The network will consist of 120 stations of which 80 stations will use real time data transmission and at least two quality sea level recordings. Solar cell power supplies for each station have been installed to ensure an availability of backup power for continuous measurement.

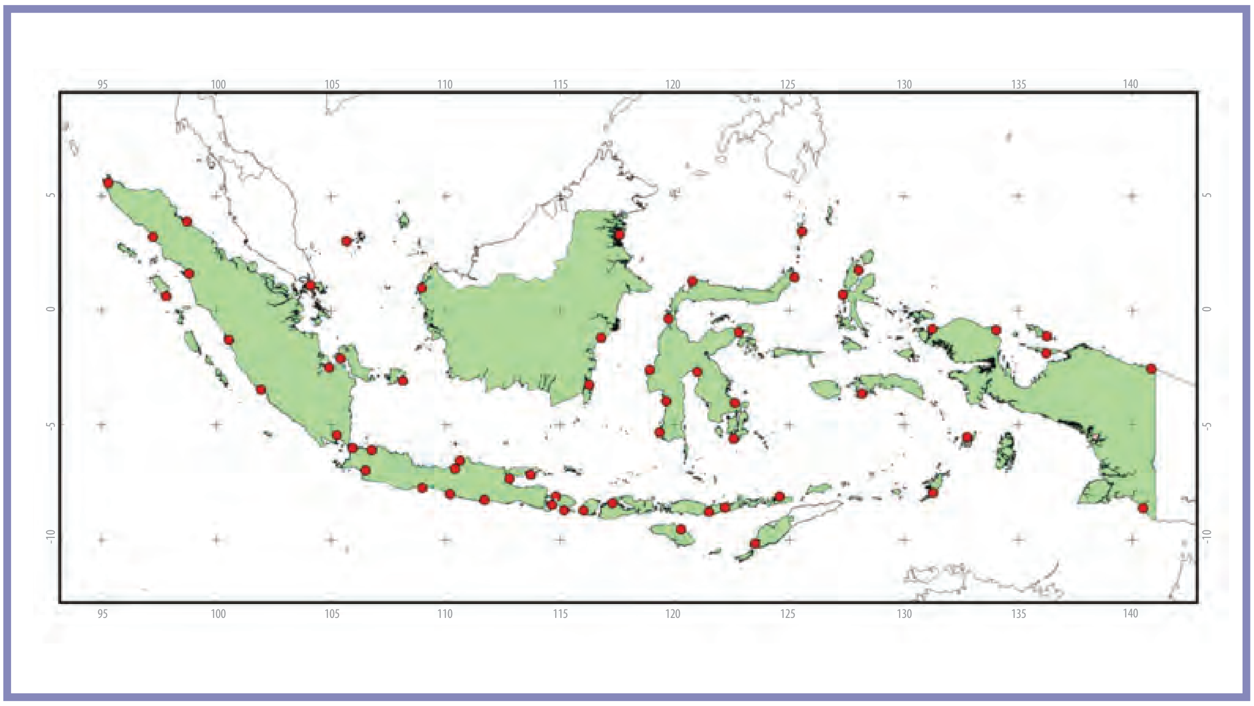


Figure 6.2 Existing operational Sea Level Monitoring Stations in Indonesia (MoE, 2008)

The National Network of Agroclimatic Stations has also been installed in a number of agriculture research stations. The network is maintained by the National Agency for Agriculture Research and Development. There are about 59 agroclimatic stations but stations in good condition are around half (Surmaini et al., 2010). The distribution of the agroclimatic stations is presented in Figure 6.3.

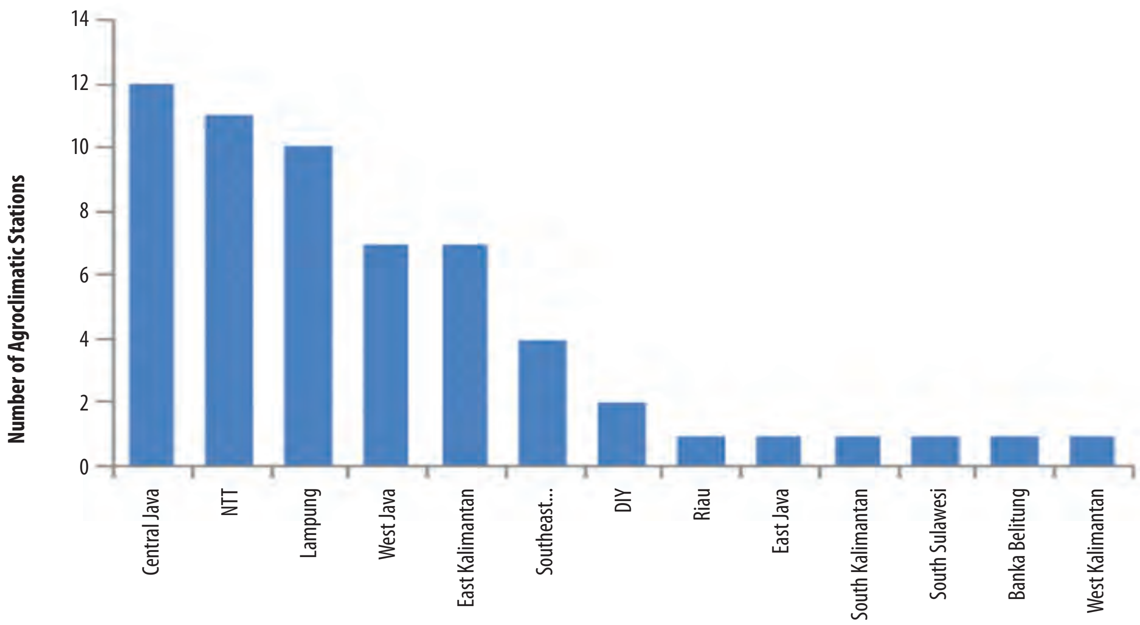


Figure 6.3 Number of agroclimatic stations by province (Surmaini *et al.*, 2010)

In forestry sector, development of systematic forest and land use monitoring systems is also crucial to support the implementation of programs for reducing emission from deforestation and forest degradation. The Government of Indonesia is in the process of establishing Indonesia's National Carbon Accounting System (INCAS), based on Australia's system but tailored to Indonesia's (INCAS) unique circumstances. The INCAS will provide a comprehensive and credible account of Indonesia's land based emissions profile and sinks capacity. It will support Indonesia's reporting requirements under the United Nations Framework Convention on Climate Change (UNFCCC) and the Reduced Emissions from Deforestation and Forest Degradation post-2012 global climate protection regime. The INCAS will contribute significantly to Indonesia's carbon accounting, resulting in positive implications both domestically and internationally. It will allow Indonesia to develop a robust modeling and projections capacity for land based carbon accounting, and therefore robust emissions and removal estimates.

The INCAS will pull together information on deforestation, land use change and land use from Indonesia's forest lands and other lands (primarily agricultural lands) to:

- support Indonesia's position in the international development of policy and guidelines on sinks activity and greenhouse gas emissions and their mitigation from land based systems

- Reduce the scientific uncertainties (particularly about peat) that surround estimates of emissions and removals of both CO_2 and non-CO_2 greenhouse gases from land use change.
- Provide monitoring capabilities for existing emissions and sinks, and scenario development and modeling capabilities that support greenhouse gas mitigation and the sinks development agenda through to 2010 and beyond.
- Provide the scientific and technical basis to international negotiations and promote Indonesia's national interests in international fora.
- Develop a comprehensive GIS that includes digital map-based information such as soil maps, remotely sensed images covering the whole of Indonesia and climate and vegetation data.
- Support Indonesia's negotiations on REDD and provide the necessary inputs required for establishing a credible Reference Emission Level.

In relation to forestry sector, Indonesia is developing Indonesia's Forest Resource Information System (FRIS). FRIS will be a comprehensive and transparent information management system to support effective planning and forest management decision making for forest lands in Indonesia. The FRIS will allow the Ministry of Forestry to monitor forest productivity, yield and growth, harvesting rates, age class, species and forest area among other things. It will also compile critical information on deforestation, land use and land use change within Indonesia's forest lands to support a post-Kyoto climate protection regime that seeks to reduce emissions from deforestation and forest degradation (REDD). Combining this data within a single system will provide a good basis for planning and decisions on sustainable forest management.

A lack of reliable information on forest resources has been identified as a major impediment to sustainable forest management in Indonesia. Such information gaps are hampering efforts to monitor deforestation and forest degradation, sustainably manage forest resources, combat illegal logging, protect biodiversity and reduce carbon emissions from land use change. Improving forest information is crucial in the context of the emerging need for the Government of Indonesia to document carbon stocks in forests and greenhouse gas emissions related to land use change and to participate in carbon markets for avoided deforestation and degradation.

6.4 Information on Education, Training, Public Awareness and Capacity Building

Between 2000 and 2008, there were about 91 training, public awareness and capacity building activities related to climate change conducted in Indonesia. This record may be much lower than the actual activities since many of climate change capacity building activities have not been recorded by related agencies. There is no system in place at present to record and monitor the outcome of the activities. However, this data may reflect the level of Annex 1 participation in supporting capacity building programs in Indonesia. The data suggests that most capacity building activities were supported by Japan, Germany, ADB and the World Bank (Figure 6.4). Again, the number of activities does not necessarily reflect the amount of funding being provided. A number of government agencies, local NGOs and universities also conducted such activities with the national budget. Furthermore, types of capacity building activities conducted before 2006 were dominated by workshops and after 2006 most of activities were in the form of climate change seminars. The number of climate change capacity building activities tended to increase after 2000 (Figure 6.5).

6.5 Efforts to Promote Information Sharing

BMKG is the main agency responsible for producing climate information used in various ways for sharing information. Climate forecasts information is disseminated through media and printed materials. These printed materials are disseminated to all provinces and sectors. In 2008, BMKG started to develop a Web-based climate information system. The system was initially developed in four regional offices (Palembang, Semarang, Makasar and Banjarbaru; Figure 6.6). This effort is continuing to be expanded to 34 Meteorological Stations all over Indonesia.

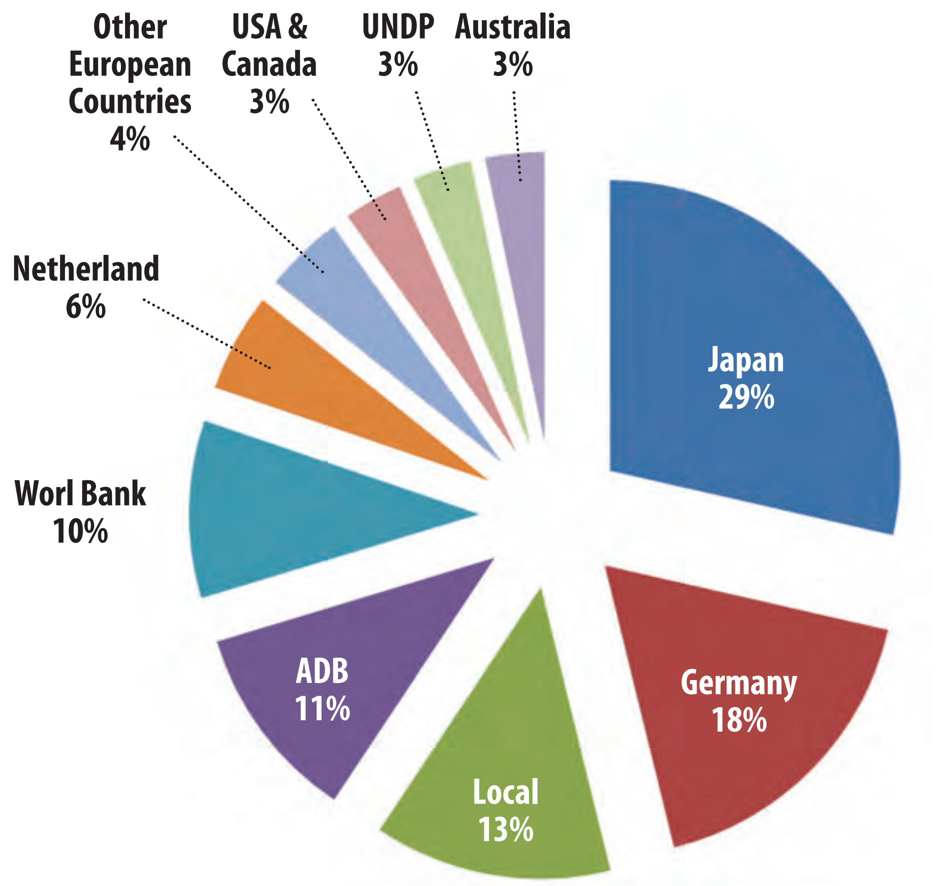


Figure 6.4 Donor countries/agencies who contribute to the implementation of capacity building activities on climate change (Based on data collected from the Ministry of Environment)

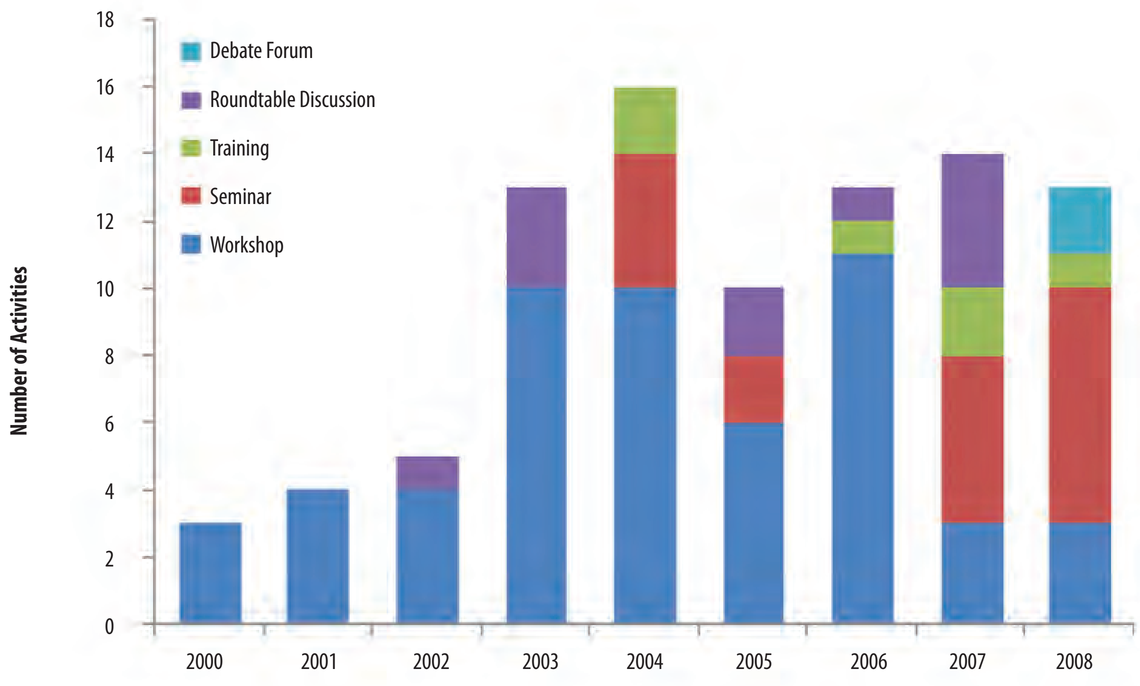


Figure 6.5 Types of capacity building activities on climate change by year (Based on data collected from the Ministry of Environment)

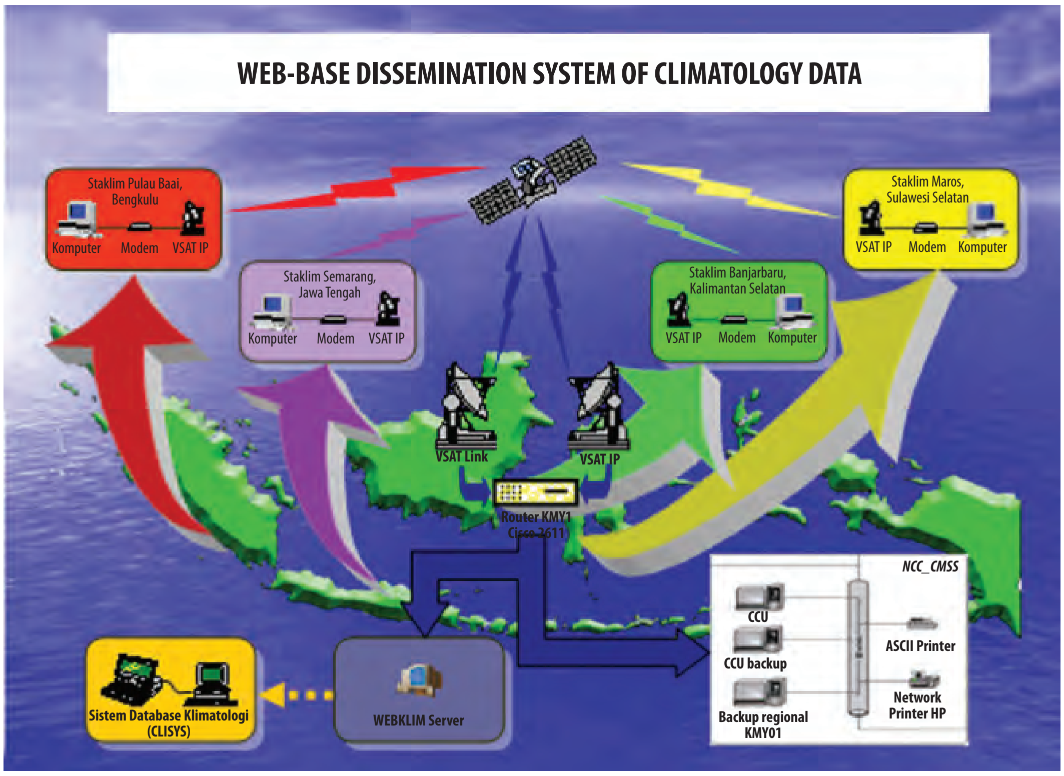


Figure 6.6 Development of web-based climate information system at four regional offices (Provided by the BMKG)

CHAPTER VII

OBSTACLES, SHORTAGES AND NEEDS RELATED TO FUNDING, TECHNOLOGY AND CAPACITY

As a country with high vulnerability to the impacts of climate change, Indonesia must have a response to address climate change both in mitigation and adaptation activities. However, in its position as developing country, Indonesia has several limitations in funding in the frame of climate change anticipation as well as developing and disseminating environmentally friendly technology. Therefore, the problems of technology transfer and funding are two issues that should receive support from international community. Additional important activities, which will ensure success of mitigation and adaptation program, are awareness, education, empowerment and capacity building.

Different from climate change mitigation, climate change adaptation has received limited attention from key-stakeholders in Indonesia and donors. Consultations reveal that various activities are ongoing, but that there is an urgent need to start systematically addressing climate change adaptation in a coordinated manner. Coordination within and between the governments and the donor communities is challenging. Activities related to climate change adaptation are still limited but likely to increase rapidly. Both government and development partners have expressed the need to ensure that addressing climate change adaptation will be effectively coordinated. This is of great importance considering the expected scale of required interventions. It has become clear that the national capacity needs to be substantially strengthened, especially in terms of policy advice, technical assistance, and capacity development.

From national consultation, it was revealed that strengthening national capacity to adapt to increasing future climate will need (UNDP CO, Jakarta, 2007):

1. Strong political consensus and multi-sectoral policy coordination among key-stakeholders to address climate change adaptation in the framework of national development planning needs. Climate change, a cross-sectoral issue, will require long term commitment. Key-ministries, institutions and development partners should have a common platform on the necessity to address climate change adaptation. Full support for the process of developing a national strategy and a longer-term programme is essential. Related to the future implementation of the strategy and programme, donor coordination and dissemination of information should be strengthened.

2. A broadly supported National Strategy for Climate Change Adaptation developed in a transparent and consultative manner.

3. Availability of a longer-term climate change adaptation programme. Considering the complexities, scale and cross-sectoral nature of climate change impacts, the programme should provide an umbrella framework to systematically address climate change adaptation at the national, regional, and local levels. Expertise and experience from all these levels and abroad will be brought in the preparation to ensure a comprehensive and high quality programme. Active involvement of the key-stakeholders, particularly of the relevant ministries, institutions and development partners is needed to ensure the programme is fully supported in its development and implementation.

7.1 Climate Change Funding

Due to limitated funding capacity through the national budget, the GOI Indonesia will try to create various funding schemes, from domestic sources as well as from bilateral and multilateral sources to support the national planning effort on climate change mitigation and adaptation. The GOI recognizes several funding mechanisms as important vehicles for climate change related activities (see Figure 7.1), as follows:

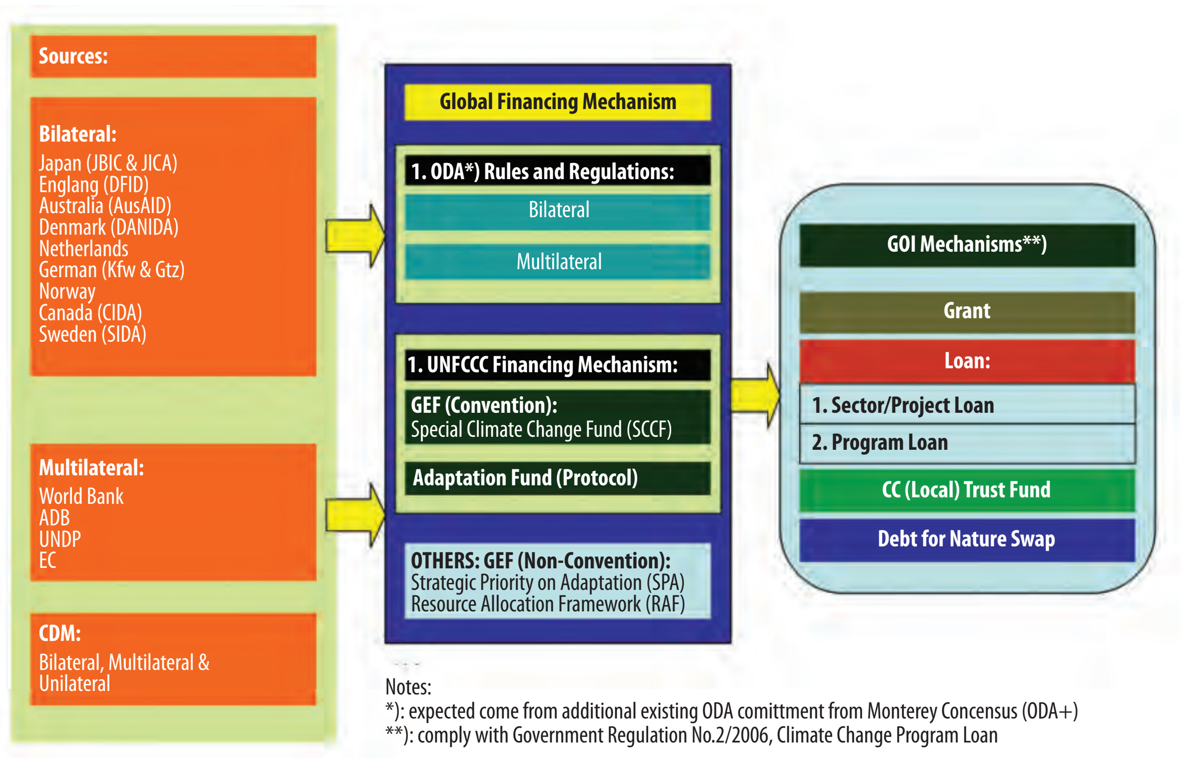


Figure 7.1 Climate Change Financing Scheme (BAPPENAS, 2009)

1. United Nation Convention for Climate Change (UNFCC) mechanism: Global Environmental Fund (GEF), Special Climate Change Fund (SCCF), Adaptation fund (Protocol)
2. Official Development Assistance (ODA) mechanism:
   a. Current scheme:
      - Bilateral grant and multilateral institution (ODA and ODA+)
      - Loan (ODA dan ODA+):
      - Sectoral/project loan – funds activities in a specific sector or project
      - Program loan – support policy reform on climate change and fiscal deficit
   b. Alternative scheme:
      - Trust Fund International (Climate Investment Fund/CIF - ODA)
      - Indonesian Climate Change Trust Fund Indonesia (Managed by GOI and Donors) – (ODA)
3. Carbon investment: Bilateral, Multilateral, and Unilateral

The GOI will apply the rule and procedures under UNFCC and ODA financing mechanism for climate change financing schemes. The GOI prioritizes grant utilization to finance climate change sectoral priorities implementation. Loan resources can only be utilized when grant funding is insufficient. However, utilization of loans should be the last alternative for climate change financing. Climate change grant financing must comply with the following guidance:

1. Grant financing focus on sector priorities as mentioned in National Development Planning Response to Climate Change called the Yellow Book
2. Grant financing that originates from UNFCC, ODA, or other financing mechanism must comply with GOI laws and regulation
3. Grant financing must be recorded into the state budget and must follow the Decree of Director General on State Treasury No. PER-67/PB/2006 on Procedures on Registration and Legalization of Foreign Grant

To efficiently and effectively utilize the foreign financing that has been allocated to address climate change related problem, then strengthening the project planning system, improving the monitoring and evaluation system, and synchronizing the financial and procurement systems between government and donors should continuously be made. Taking these steps will ensure that foreign grants and loans match national development priorities and leads to an enhanced level of accountability.

7.2 Technology

Research and technology are needed to adapt and mitigate climate change. Low carbon emission and energy efficient technology is needed immediately to reduce GHG emission in the sectors that consume energy such as power plants, industry, transportation, as well as household and commercial sectors. Real time monitoring and the use of sophisticated fire fighting technology and peat management is required to control emission from forest/peat fire and peat decomposition. Peat lands store large amounts of carbon stocks that, if released, can greatly contribute to global climate change. Although there are many uncertainties regarding Indonesia's GHG emissions, it is generally agreed that peatland degradation is the main source, together with deforestation. Proper management of peatlands is therefore critical to Indonesia's efforts in combating climate change.

Furthermore, for adaptation need in agriculture sector, technology to develop plant varieties that are resilient to climate change impact is required. Agricultural technology that saves water also should be implemented to anticipate water scarcity during longer dry seasons. To increase the preparedness of various parties in addressing the conditions of extreme climate, Indonesia needs weather prediction technology that can produce more accurate results. With this technology, fisherman and farmers can plan more proactively for their activities, thus reducing the losses that they may suffer because of the extreme climate and weather events (drought, storm etc.). In addition, early warning technology should also be implemented to reduce the general public's exposure to the negative impacts related with extreme climate. International cooperation and transfer of technology should be strengthened to share the benefit of technological knowledge worldwide. Indonesia needs to prioritize the development of low-cost technologies with substantial local content.

Indonesia assigns priority to climate change adaptation programs in the four following areas: (i) coastal areas, (ii) food insecure areas in eastern Indonesia, (iii) small islands, and (iv) Java's northern coast, the nation's key rice production areas (BAPPENAS, 2009). Coastal areas are among the areas most affected by sea-level rise and land subsidence-induced environmental degradation. Both have exposed coastal areas to regular flooding and have significant economic and social impacts. As these communities are at the forefront of adapting to climate change, focused regional approach is warranted. Investing in coastal areas to adapt to sea-level rise is a key to meet the MDGs.

In food insecure areas in eastern Indonesia such as Sulawesi, NTT and NTB, the ENSO signal is very strong (Gianinie et al., 2007; Moron *et al.*, 2009). Strong El-Niño events normally cause the problem of false rains, in which isolated rainfall events around the expected onset date do not signal the sustained onset of the monsoon thus shortening the length of rainy season. This condition leads to farmers experiencing repeated crop failures and rendering it possible only to plant crops once in that year. Crop failure due to drought during the 2006/07 El-Niño for example, increased the reliance of NTT farmers to government aid. In normal years, contribution of government aid to farmers' total income was only 5% but in 2006 El-Niño year, it increased to 60% (Kieft and Soekarjo, 2007). This, combined with already low general human development, has triggered a decline in child health nutrition, a key MDG indicator. Current development approaches employed have proven ineffective, thus calling for efforts to enhance local capacity to adapt to the changing climate.

Java's northern coast is also strongly affected by ENSO. Local action will place an emphasis on the provinces of West and East Java. Increased pressure on these lands due to continued urban growth and relative limited expansion of agricultural lands outside Java has deepened the strategic importance of the Java "rice basket" to ensure national food security. Increased frequency of ENSO events is leading to increased crop losses in these areas. An integrated approach that is smallholder-driven and that includes technology development and spatial planning is a key.

Sea level rise and changing rainfall patterns in combination with extreme wave and high tide are threatening small islands. These undermine the local economy and ecology and may also lead to the loss of the small islands. Programs in these areas should focus on enhancing general human development while strengthening ecological sustainability. More effort will be put on developing adaptation and mitigation measures for small islands.

To increase the resilience of the sectors and community to current and future climate risk, the development and implementation of a comprehensive communications strategy to increase the capacity in using climate information is needed as well as institutionalizing the use of climate information. The development and promotion of tools for adaptation planning tailored to user's requirements that include (i) decision-support tools such as methods for assessing the costs and benefits of adaptation strategies, and guides for risk management, (ii) methods for understanding social impacts, and (iii) a national 'one stop shop' website where decision-makers and their advisers can access information about climate projections, likely climate change impacts, tools, guides and approaches to adaptation planning will be required.

7.3 Awareness, Education, Empowerment and Capacity Building

Raising the awareness of every citizen on the importance of climate change and integrating climate change issues into national education is essential to ensuring public buy-in and the success of mitigation and adaptation programs. Changing human behaviour in order to respect natural environment, and thereby minimizing human impacts on the environment, must occur at all level of society. Climate change is an effective entry point to raise public awareness about the need to develop in a more responsible and suitable manner.

Human resources will need to be strengthened to ensure the efficient and effective implementation of climate change initiatives. Capacity building and empowerment of all related stakeholders will take place, with emphasis on local government and civil society as they will be the key implementers of change at the regional and local level. Capacity building will include immediate steps as well as longer-term efforts and it will consider the complexity of the many sectors involved in climate change.

Our knowledge on the uncertain future climate and its impact is still limited. In spite of this uncertainty, the ability to generate access and interpret information on climate change and its likely impacts is crucial. Further, it is equally important to develop suitable methods for identifying and assessing potential adaptation strategies. Knowledge and methods will need to span across disciplines, including climate science, biophysical sciences, engineering, social sciences, economics, and planning. Implementation of pilot projects on addressing climate change is very important to generate best practices on how we can improve our resilience to future climate risk.

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