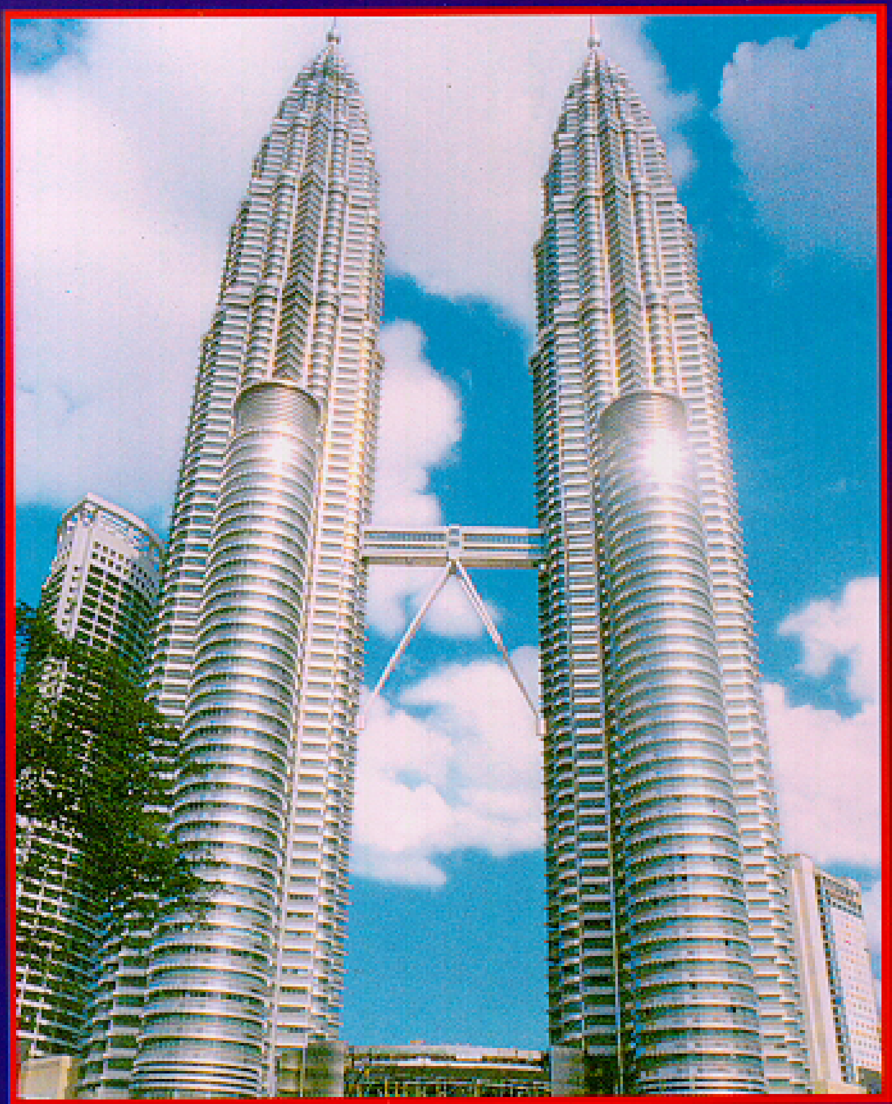
Malaysia

Initial National Communication



submitted to the

United Nations Framework Convention on Climate Change

MINISTRY OF SCIENCE, TECHNOLOGY AND THE ENVIRONMENT

July 2000

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Foreword

On behalf of the Malaysian Government, I am pleased to present the Initial National Communication to the United Nations Framework Convention on Climate Change (UNFCCC). The National Communication outlines Malaysia's efforts in addressing the causes and impacts of climate change, and the various strategies that have been and will continue to be pursued, within the overall sustainable development framework, to achieve national development goals while meeting our commitments under the Convention.

Malaysia's net greenhouse gas (GHG) emission was estimated at 3.7 tons of CO_2 equivalent per capita in 1994. This places Malaysia among the lowest emitters of GHG compared to most industrialised countries which emit up to 20 tons of CO_2 equivalent per capita. This has been achieved through, among others, efficient use of both renewable and non-renewable energy, use of efficient modes of transportation and conservation and sustainable use of forests. Developing countries need further economic development through industrialisation and this will certainly cause an increase in GHG emissions in the future. It therefore becomes imperative for the international community to honour their commitments, based on the principle of common but differentiated responsibility, to provide adequate resources to implement the various strategies that have been outlined to ensure effective reduction of greenhouse gases.

I take particular pride in the fact that the preparation of the Initial National Communication was totally country-driven and was undertaken by national experts drawn from the public and private sectors and the NGO community. This has enabled us to gain a better understanding of the complex nature of climate change, and more importantly, has forged a meaningful relationship among stakeholders to undertake, in a co-ordinated manner, future measures to address climate change.

I wish to congratulate all those involved for this excellent report. My appreciation also goes to the Institute of Strategic and International Studies (ISIS) Malaysia, as the project manager; and the Global Environmental Facility (GEF) and the United Nations Development Programme (UNDP) for their financial support.

DATO LAW HIENG DING
Minister of Science, Technology and the Environment, Malaysia

Executive Summary

Introduction

This initial National Communication (NC) has been prepared under the stewardship of the National Steering Committee chaired by the Ministry of Science, Technology and the Environment. For the preparation of this NC, the Second Conference of Parties guidelines and the 1995 Intergovernmental Panel on Climate Change (IPCC) methodologies for the inventory of greenhouse gas (GHG) emissions were adopted, using the reference year 1994.

This NC sets out, *inter alia*, the national inventory of GHGs and the assessment of the possible impacts of climate change, and makes suggestions for possible initiatives to address this issue. The NC also makes reference to several mechanisms and measures that represent policy responses to promote sustainable development efforts that the Government has been pursuing for many years.

Environmental and Sustainable Resource Management

Malaysia has endeavoured, since the 1970s, to introduce a variety of measures to achieve sustainable development goals which have been embodied in relevant policies and all short-, medium- and long-term development plans, such as, the five-year development plans, Outline Perspective Plans, and Vision 2020. The Government has also introduced energy efficiency measures, such as, energy efficiency guidelines for buildings, improvement of road systems, and construction of light rail transit and electrical rail systems. Other strategies include promulgation of environmental and related regulations and their enforcement, land use planning and increasing public awareness. Environmental monitoring and surveillance have been carried out vigorously to ensure compliance with environmental standards and to reduce violations. Regulations on the management of toxic and hazardous waste have been established and a centralised integrated facility was commissioned to handle such wastes.

In the management of natural resources, the Government has adopted an integrated approach towards attaining both environmental and developmental objectives through various measures. These include imposing Environmental Impact Assessment for prescribed activities, delineating areas as Permanent Forest Reserves for the protection of forests, deciding on a long-term commitment to maintain a minimum of 50% forest cover, and launching a National Policy on Biological Diversity. In addition, the Government has established national and marine parks, wildlife reserves, and sanctuaries, enacted various legislation to protect land, coastal and marine resources from soil erosion, air and water pollution, and taken steps to conserve the nation's energy sources and mineral resources by rationalising oil and gas production.

Inventory of Greenhouse Gas Emissions

Malaysia's greenhouse gas (GHG) emissions totalled 144 million tonnes in terms of carbon dioxide (CO_2) equivalent in 1994. Net emissions, after accounting for sinks of 68 million tonnes, amounted to 76 million tonnes CO_2 equivalent. On a per capita basis, net emissions amounted to 3.7 tonnes CO_2 equivalent.

In terms of GHGs, CO_2 accounted for 67.5%, methane (CH_4) 32.4% and nitrous oxide (N_2O) 0.1% of total CO_2 equivalent emissions. The fuel combustion energy sector accounted for 86.7% of total CO_2 emissions, land fills (46.8%) and fugitive emissions from oil and gas (26.6%) accounted for 73.4% of total CH_4 emissions, and traditional biomass fuels accounted for 86.4% of total N_2O emissions.

In estimating GHG inventories, a conservative approach was adopted, that is, default values and data sets used represent the worst possible scenario in terms of GHG emissions, and therefore the inventory computed represents the upper limits of GHG emissions. If specific values and more reliable data sets had been available, Malaysia's net GHG emissions would arguably have been much lower. Also, it is to be noted that emissions from the energy sector were based on supply or reference point data sources. An estimate based on consumption or demand side calculation shows that the GHG emissions were only half of the supply side estimation.

Malaysia's experience during this exercise revealed that the IPCC methodologies need to be further refined, particularly taking into account local conditions. There is also a need to systematically develop appropriate databases so that a realistic estimate of inventory can be made.

Impacts of Climate Change

An analysis of temperature records in Malaysia shows a warming trend. For the assessment of the impacts of climate change on agriculture, forests, water resources, coastal resources, health and energy sectors, temperature changes ranging from +0.3°C to +4.5°C and rainfall changes ranging from –30% to +30% were used. Several fixed sea level rise scenarios within the range of 20–90 cm in 100 years were adopted for the assessment of impacts on coastal resources.

Climate change can reduce crop yield. Areas prone to drought can become marginal or unsuitable for the cultivation of some of the crops, such as, rubber, oil palm, cocoa and rice, thus posing a potential threat to national food security and export earnings. As much as 6% of land planted with oil palm and 4% of land under rubber may be flooded and abandoned as a result of sea level rise.

Forests, however, are more vulnerable to land use change than to climate change. Upland forest can be expected to expand by 5% to 8%, but this could be nullified by a loss of between 15% and 20% of mangrove forests located along the coast as a result of sea level rise. Disease infestation on forest plantation species may be aggravated by climate change. The impact of climate change on Malaysia's rich biodiversity is also of great concern, where, with the intricate interrelationships between plant and animal species, the impact on any one species can have consequences for other species as well.

Increasing temperatures will result in higher evapotranspiration leading to reduction in water availability. This problem will be further exacerbated during the dry months. On the other hand, an increase in storm magnitudes will result in an increase in the frequency and intensity of floods and, therefore, flood damage.

The impact on coastal resources can be classified into four broad categories. The first is tidal inundation, where about 1200 km^2 in Peninsular Malaysia alone will be submerged subsequent to bund failure, and mangroves will be lost if sea level rises at a rate of 0.9 cm / year. The second is shoreline erosion, which will account for another few hundred metres of shoreline retreat. The third is increased wave action, which can affect the structural integrity of coastal facilities and installations such as power plants. The last is saline intrusion, which can pose a potential threat of water contamination at water abstraction points. Examples of other impacts include submergence of corals, coral bleaching due to increasing levels of CO_2 in the water, and depletion of fisheries resources due to loss of mangrove habitats.

Climate change is also expected to cause adverse health consequences. A direct impact could be deaths due to heat stress or respiratory diseases due to air pollution, while indirect effects could include increased food and water-borne diseases, resulting from changes in rainfall pattern. There could also be an increase in vector-borne diseases – such as, malaria and dengue fever – as changes in temperature will increase the availability of suitable breeding habitats for the vectors.

In addition climate change will have adverse impacts on electricity production and consumption, and the oil and gas industries. Operational and maintenance costs of electricity producers will be substantially increased to provide the necessary protection for power plants located along the coasts due to increased coastal erosion. A rise in air and water temperature will reduce plant efficiency and power output leading to higher production costs. There will also be an increase in the consumption of electricity if there is a rise in the air temperature, as it would result in an increased use of air-conditioning. Oil and gas industries and associated coastal facilities will be similarly affected.

Research and Systematic Observation

The Malaysian Meteorological Service (MMS) continuously monitors and carries out analyses to detect climate change. Presently, MMS is developing a regional climate model that will assist future development of national climate scenarios. MMS has also been operating a network of stations across the country to monitor various meteorological variables at the surface and in the atmosphere for more than 50 years. These observations are further supplemented by rainfall records from the Department of Irrigation and Drainage, which also monitors river stage and discharge, and suspended sediment, to aid basic water resource assessment and in flood forecasting and warning. The Malaysian Department of Survey and Mapping conducts tidal observations for the determination of mean sea level as reference for the National Geodetic Vertical Datum.

Education, Training and Public Participation

Concerns over environmental issues among the Malaysian public vary widely. Few people, however, are able to relate their everyday activities which contribute to the emission of GHGs to environmental consequences, both in the short- and long-term; fewer still have knowledge about the various institutional initiatives being taken at the local, national, regional, international, multilateral or global level to improve the environment. The Government has adopted a long-term strategy to carry out environmental education at pre-school through to tertiary level. Meanwhile, non-governmental organisations, the mass media and the private sector are complementing the Government's efforts in promoting environmental education. Relevant government agencies also organise various programmes to enhance the public's awareness of the state of the country's environment.

Identifying Strategies to address Climate Change Issues

Various measures have been identified, aimed at enhancing scientific knowledge and understanding, strengthening institutional capacities in terms of better database support, increasing technical skills, promoting closer interagency collaboration, and mitigating GHG emissions. These measures include carrying out comparative studies on carbon sequestration potentials of forests, which would provide a deeper understanding of the role of forests as sinks. Improving energy efficiency in the transport and industrial sectors, use of biomass waste for power co-generation, introduction of the use of photovoltaics in urban areas, and the development of Demand Side Management programmes are also some of the considerations which would require extensive studies of existing and emerging technologies and testing the applicability of such technologies. A strategy to heighten public awareness through the mass media has also been identified.

1. Introduction

Malaysia signed the United Nations Framework Convention on Climate Change (UNFCCC) on 9 June 1993 and ratified it on 17 July 1994. Subsequently, the Government established a National Climate Committee comprising the Ministry of Science, Technology and the Environment (MOSTE) as Chair, and representatives from relevant sectors to help meet its obligations under the Convention. The Malaysian Meteorological Service (MMS), which is under MOSTE, was designated as the Secretariat to the Committee.

Malaysia is committed, among others, to prepare Malaysia's National Communications (NC) to the UNFCCC. To guide this initial NC, a National Steering Committee was formed under the chairmanship of MOSTE. The work of preparing this NC was entrusted to the Institute of Strategic and International Studies (ISIS) Malaysia, which assembled a team of local experts from different backgrounds to prepare a series of base reports upon which the NC would be premised.

This initial NC was prepared in close adherence to the guidelines adopted by the Second Conference of Parties (COP2) in decision 10/CP2. Baseline information was pegged to the year 1994. The 1995 Intergovernmental Panel on Climate Change (IPCC) methodologies were adopted in the preparation of national greenhouse gas (GHG) inventories.

This NC sets out, *inter alia*, the national inventory of GHGs and the assessment of the possible impacts of climate change, and makes suggestions for possible initiatives to address this issue. The NC also makes reference to several mechanisms and measures that represent policy responses to promote sustainable development efforts that the Government has been pursuing for many years.

Malaysia agrees and supports fully the principles of the Convention. As a developing country, Malaysia's top priority, however, is to eradicate poverty and upgrade the living standards of its people. Nevertheless, as a responsible member of the international community, and based on the principle of common but differentiated responsibilities under the Convention, it will, given the necessary resources and technology, continue to work with all countries to ensure global environmental well being.

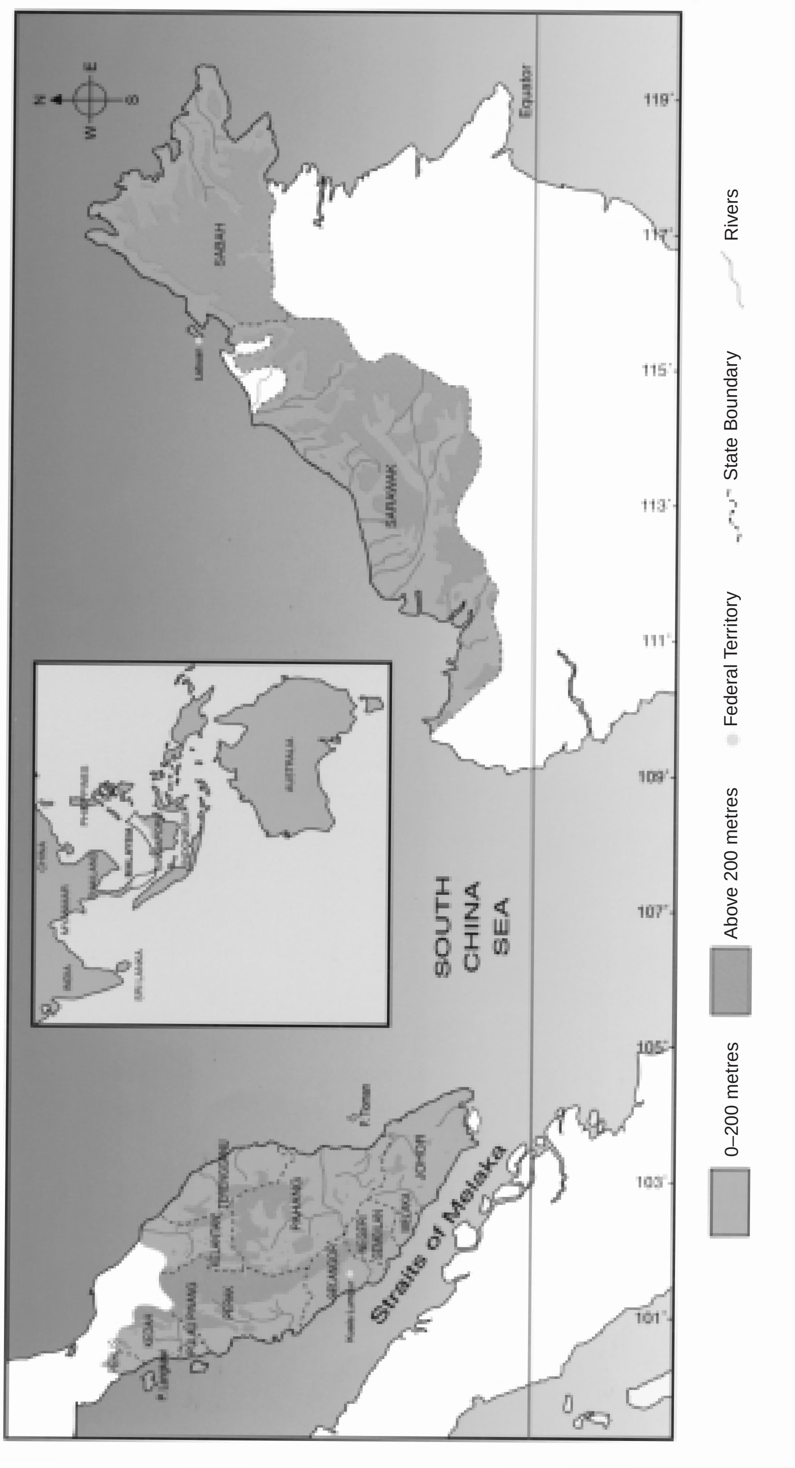
2. National Circumstances

Geography

Malaysia is a coastal nation, rich in biodiversity and natural resources. The country covers an area of 329,733 km^2 and is divided into two landmasses that are separated by the South China Sea. Peninsular Malaysia, in the west, has an area of 131,573 km^2 and is composed of 11 states and the Federal Territory of Kuala Lumpur. Two other states, Sabah and Sarawak, occupying an area of 73,619 km^2 and 124,449 km^2, respectively, and the Federal Territory of Labuan are located in the northwestern coast of Borneo island. The entire country is situated in the equatorial region, with Peninsular Malaysia lying between latitudes 1.5°N and 7°N and longitudes 99.5°E and 104°E. Sabah and Sarawak are located between latitudes 1°N and 6.5°N, and longitudes 108.5°E and 120°E. The map of Malaysia is shown in Figure 2.1.

Mountain ranges run the length of both Peninsular Malaysia and the Sabah-Sarawak states. Human settlements are concentrated along the alluvial plains towards the coast, leaving much of the country under forest cover on hill-slopes and foothills. Specific locations in the country such as coastal areas, which are home to more than 60% of the total population of Malaysia, are likely to be much more sensitive to the impacts of climate change. Vegetation types in the cooler upland regions, delineated by temperature limits, will also be affected by global warming. Several areas are prone to drought, and climate change may therefore aggravate such drought conditions. Further, since most coastal regions are low-lying, areas that are less than 0.5 m above the highest astronomical tide, or are within 100 m inland of the high-water mark, would be especially vulnerable to the effects of sea-level rise. Polders are currently protected by bunds, but they too may be inundated by sea-level rise. Mangroves currently fringe many parts of the coastline. If limited sea-level rise does occur, the mangroves could be forced to retreat further inland, but this could be constrained by hinterland development.

Figure 2.1: Map of Malaysia



Climate

Malaysia experiences relatively uniform temperatures throughout the year. The mean temperature in the lowlands ranges between 26°C and 28°C, with little variation in the different months or across different latitudes. Although the annual variation of the daily mean temperature may be small (about 2°C to 3°C) the diurnal variation may be as large as 12°C. The average lowland station can record temperatures from about 20°C to 32°C in a day. Air temperatures of 38°C and above have very rarely been recorded.

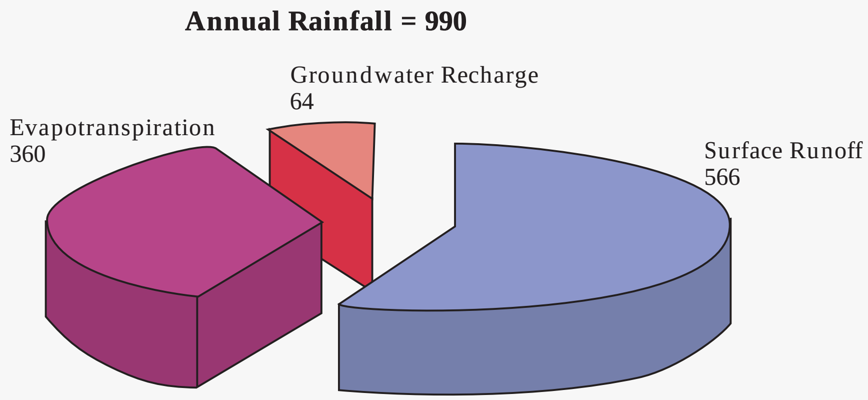
Seasonal variations in climate are more evidently marked by rainfall patterns, which in turn closely mirror changes in the monsoon winds blowing at different times of the year. The Northeast monsoon is dominant from November to March, with wind speeds of 15 km/hr to 50 km/hr. Between June and September, the Southwest monsoon winds blow with wind speeds seldom exceeding 25 km/hr. The Northeast monsoon brings moisture, while the pattern of rainfall distribution closely follows the topography of the land with highlands being generally wetter. Over 3,550 mm of rainfall a year are being recorded in the lowlands. Pockets of areas located in-between highland ridges fall within the rain-shadow, and hence receive less than 1,780 mm of rainfall a year. During the brief inter-monsoon months, rains and often thunderstorms result from convection currents.

Water Resources

Located within the humid tropics, Malaysia is endowed with abundant water resources. Annual rainfall received totals 990 billion m^3. The annual surface runoff is estimated at 566 billion m^3 – 147 billion m^3 in Peninsular Malaysia, 113 billion m^3 in Sabah, and 306 billion m^3 in Sarawak. The groundwater recharge is estimated at 64 billion m^3 annually, while the balance 360 billion m^3 returns to the atmosphere via evapotranspiration (Figure 2.2). The fresh groundwater storage is estimated at 5,000 billion m^3.

The demand for water has increased steadily from 8.9 billion m^3 in 1980 to 11.9 billion m^3 in 1990 for agricultural, industrial and domestic

Figure 2.2 The Annual Water Balance (in billion m^3)

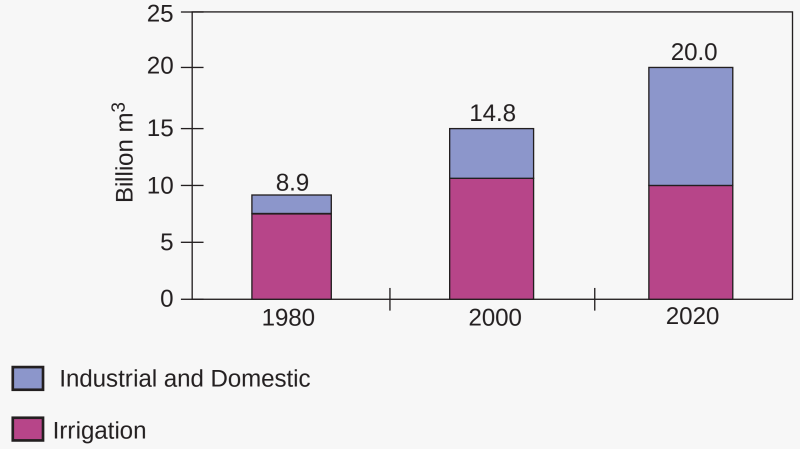


Source: National Water Resources Study, Malaysia, October 1982

purposes. Usage of water for irrigation, which accounted for about 83% of total water usage in 1980, increased to about 9.5 billion m^3 in 1995. This amount of water irrigated eight large paddy granary schemes and 924 smaller schemes, with a total combined area of 340,000 ha. Total domestic and industrial water supply in 1995 accounted for 8,200 million litres per day (mld), reaching more than 98% and 78% of the urban and rural population, respectively. More than 98% of the current water use originates from surface water resources. Groundwater only accounts for less than 2% of the current water use. Water demand is expected to reach 14.8 billion m^3 by the year 2000. Generation of hydropower, navigation and recreational activities account for the main non-consumptive uses of water.

From the year 2000, it is anticipated that, with the Government's continued emphasis on industrialisation programmes to boost economic growth, industrial and domestic water usage will continue to increase. The demand in these sectors is expected to constitute about 48% of the total 20 billion m^3 by the year 2020. Figure 2.3 shows the rapid increase in the water demand ratio in the industrial and domestic sectors compared with irrigation needs in the agriculture sector.

Figure 2.3: The Annual Water Demand Projection (in billion m^3)



Source: DID.

The projected water demand of 14.8 billion m^3 up to the year 2000 constitutes less than 3% of the surface water resources available in the country. Unfortunately, due to the uneven distribution of rainfall in time and space, the availability of water resources is uneven. This fact, coupled with rapid growth in urban areas (such as the Klang Valley, Melaka and Pulau Pinang) as well as high water usage in granary schemes (such as the Kemasin-Semarak Paddy Schemes in Kelantan), is causing sporadic water shortages in these high water demand areas. Inter-state water transfer facilities have been implemented in some of the areas facing water shortages, such as those from Johor to Melaka, and from Kedah to Pulau Pinang. Schemes for such facilities could become a prominent feature of national water resource development in the near future as more areas become stressed due to rapid socio-economic and industrial development. Besides water availability, access to uncontaminated water is also becoming an important issue.

Some low-lying areas experience floods particularly during the Northeast monsoon season. Since 1960, there have been seven major floods, the most severe and extensive ones occurring in 1967, 1971 and 1973. It is estimated that 29,000 km^2 of the total land area are flood-prone, affecting 15% of the total population in Malaysia. The annual flood damage is estimated at RM100 million (at 1980 prices).

Social Framework

Malaysia is a multi-ethnic and multi-cultural society. Of the total population of 20,111,600 in 1994, Malays and other Bumiputeras (indigenous peoples and major local communities in Sabah and Sarawak, such as, Kadazans and Dayaks) formed the dominant group (61%), followed by Chinese (28%), Indians (8%) and others (3%). The population of Malaysia had more than doubled since independence in 1957, growing from 7.4 million that year to 18.4 million in 1991 when the last population census was conducted. The average rate of annual population growth during this period was 2.5%, inclusive of a net inflow of migrants. In 1991, 81% of Malaysia's population lived in Peninsular Malaysia, with 19% living in Sabah and Sarawak. The country's population remains relatively young, with a median age of 22 years.

Malaysia's young multi-racial population are in schools, preparing to enter the workforce

Urbanisation is closely associated with economic expansion. In 1980, Malaysia's urban population was 34% of the total population. The urban population rose to 51% by 1991 and 54% by 1994. Between 1980 and 1991, the number of urban centres increased from 67 to 127.

In 1994, the working population, aged between 15 and 64 years, was estimated at 60% of total population. Of this working population, 67% (the labour force participation rate) were economically active. The service sector accounted for nearly half of the total employment. The manufacturing sector accounted for another 25%. In contrast, the agricultural and mining sectors accounted for less than 20% of total employment.

Social Integration

In order to create a just, united, peaceful and prosperous nation and society, the Government has taken various measures to reduce and eradicate poverty. The thrust of poverty alleviation measures is to reduce the incidence of poverty among Malaysians to 5.5% by the year 2000. This involves not only raising productivity and real incomes but also improving the access of the lower income group to better social services — such as education, health care, housing, and public amenities — and to better income opportunities. Implementation of the national strategy to reduce and eradicate poverty also takes into account the concerns of all communities living in both urban and rural areas. In this context, Malaysia, like many other developing countries, is often confronted with the challenge of meeting competing demands for limited resources *vis-à-vis* national priorities and international obligations.

Government Structure

Malaysia is a constitutional monarchy. The Head of State is the King (Yang DiPertuan Agong), who is elected for a five-year term by the Conference of Rulers. The Conference of Rulers comprises the hereditary Rulers (Sultans) from nine States. The heads (State Governors or Yang DiPertua Negeri) of the remaining four States are appointed by the King.

Malaysia has a bicameral Parliament, consisting of the Senate (Dewan Negara) and the House of Representatives (Dewan Rakyat). The Senators are appointed, while members of the latter are elected via a general election due every five years. The Cabinet, headed by the Prime Minister, comprises only members of the legislature, and is collectively responsible to the Parliament.

Elections to the 13 State Legislative Assemblies are also due every five years. At the State level, the Executive Council is headed by the Chief Minister (Menteri Besar). Local governments are administered by municipal councils, and by city halls in the case of Kuching, Johor Bahru, Ipoh and Kuala Lumpur. Councillors of local governments are appointed by the respective State Governments.

The highest judicial authority is the Federal Court of Malaysia, headed by the Chief Justice. The Court has jurisdiction to interpret the Constitution, besides ruling on disputes between State Governments and between the State and Federal Governments. The Federal Court is divided into the High Court and Court of Appeals. There are separate High Courts in Peninsular Malaysia, Sabah and Sarawak, each headed by a Chief Judge. The Sessions Courts, Magistrate's Courts and Penghulu's (Village Headman) Courts are subordinate courts with limited jurisdiction. There is also the Muslim religious court or Syariah Court, established by State legislature, which enforces religious observance and codes relating to domestic and matrimonial matters pertaining to Muslims.

Generally, the Federal Government has overall responsibility for environmental matters; but State Governments have jurisdiction over the management of natural resources, especially land, forestry and water.

The Economy

Malaysia had, for many years, enjoyed rapid economic growth. From 1990 until the time of the economic crisis that hit the East Asian region in the middle of 1997, the country's economy had achieved an annual average growth rate of 8.7%. At 1978 constant prices, the gross domestic product or GDP grew from RM20 billion in 1970 to RM80 billion in 1990 and RM110 billion in 1994. With a population of 20.11 million people, GDP per capita in 1994 was RM5,465. The exchange rate of the Malaysian Ringgit (RM) varied only within a narrow band averaging about RM2.50 to US$1.00 from 1991 to mid-1997. Following the East Asian economic crisis, the Government of Malaysia instituted selective currency controls in September 1998 to prevent exchange rate instability. It fixed the exchange rate at RM3.80 to US$1.00.

In 1994, exports of goods and services totalled RM109.6 billion (or nearly 100% of GDP). Imports totalled RM114.3 billion (104% of GDP), resulting in a trade deficit of RM4.7 billion (4.3% of GDP). The economy was driven by a high rate of investment with fixed capital formation amounting to RM46.4 billion (42.3% of GDP), financed largely through a high savings rate (36% of GDP). The savings-investment gap contributed towards the current account deficit of RM12 billion at current prices. This resource gap was covered to a large extent by foreign direct investments (FDI).

On the production side, manufacturing industries formed the leading sector, comprising 32% of GDP in 1994. The 1994 figures also show that the manufacturing sector grew annually at 14.9%, surpassing the 8.9% growth rate of the overall economy. Commercial services comprised 23% of GDP; the sector grew at 8.7% a year. Agriculture accounted for 11.5% of GDP, which declined marginally at a rate of 1.3% a year.

Despite the economy being adversely affected by the East Asian economic crisis in 1997, Malaysia managed to contain the crisis and thus avoided potentially extreme effects such as high unemployment, mass poverty, and civil unrest. This was due to the relatively strong initial conditions, both in terms of the real economy and the financial sector that allowed the Government to institute swift and pragmatic policies in line with the changing circumstances during the course of the crisis (*see Box*). Preliminary figures for 1998 show that the GDP contracted by 6.7%, to RM131.3 billion, in constant prices. This contraction was caused by significant reductions in private consumption and investments by 12.4% and 57.8%, respectively, and by moderate cutbacks in public consumption and investments by 3.5%

Unique Prescription for Malaysia's Economic Recovery

Under the floating exchange rate, the conversion of the ringgit with another currency depended on the forex market, which bore no reflection of the country's reserves nor its economic fundamentals. Nevertheless, the central bank bought or sold its reserves to stabilise the ringgit at around the rate of RM2.50 to US$1.00. Over the years, the forex market had become highly speculative. The daily turnover in 1995 was US$1.2 trillion compared to only US$190 million a decade before. The world's 1995 daily merchandised trade, for which foreign exchange flows are meant to represent, was only US$13.5 million. Part of this offshore capital flowed into Malaysia as foreign direct investments and helped boost industrialisation. But there was also short-term capital that helped capitalise the Kuala Lumpur Stock Exchange or KLSE, which reached RM917 billion and the KLSE index rose above 1,200 points in 1997.

Following the East Asian economic crisis, from July 1997 through to early 1998, the KLSE index collapsed to 477 points and the capitalisation fell to RM 308.7 billion. Capital repatriation of foreign-owned shares resulted in a double-blow, collapsing both the stock market and the ringgit's exchange rate. The central bank started to sell from its reserves to ease the falling ringgit but, after failing to achieve results, the ringgit was allowed to float freely on 14 July 1997. The country's reserves remained intact, but the ringgit declined to RM3.00 in September and went as low as RM4.88 in January 1998. On 2 September 1998, the central bank announced that the ringgit would be fixed by capital controls at RM3.80 to the US dollar.

The idea behind capital controls in Malaysia is to break the link between interest rates and exchange rates. Low interest rates allow cheap borrowing at home for investments abroad. High interest rates attract inflow of foreign funds looking for good returns. These capital flows change domestic money supply relative to other currencies and cause movements in exchange rates which become highly unstable with widespread speculation. To offset the falling ringgit, the textbook approach would be to allow interest rates at home to rise in tandem with changes in the ringgit's supply and demand relative to other

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currencies. The high interest should attract capital inflows that will allow the ringgit to recover.

The International Monetary Fund (IMF) prescription is the textbook approach which relies on market forces to find its supply and demand equilibrium rate of exchange. To offset the low value of the ringgit, interest rates would have to soar. It will also take time for the market to adjust. Meanwhile, the tight money situation would lead to a deep and painful recession, investments would be pulled back and unemployment would soar.

Rather than create such hardship, the Malaysian government instituted its unique and bold form of capital controls by demonetising the ringgit overseas. This suspended trading of the ringgit in the forex market. All exports and imports were conducted using the American dollar at the fixed rate. The central bank would undertake all conversions. To stabilise more volatile short-term capital flows from abroad, repatriation of funds was disallowed for a period of one year. This rule has, however, been relaxed to allow repatriation at any time with the payment of a 10% "exit" tax.

With the link between interest rates and exchange rates broken, the government could undertake both monetary and fiscal policies at home to stimulate economic recovery. Interest rates were driven down and local banks were given loan growth targets. To enable sufficient funds, the government instituted the sale of bonds and increased its foreign borrowing. By mid-1999, RM13.5 billion worth of corporate debt had been settled. To strengthen domestic financial institutions, a merger programme was introduced to consolidate commercial banks, merchant banks and finance companies.

But what are the risks of capital controls? Despite popular belief, there is no risk of a black-market because the ringgit has no value overseas. However, without a foreign exchange market for the ringgit to ensure supply and demand equilibrium, the country could run out of its foreign reserves if the fixed rate is guaranteed. The risk, in this case, is minimal because Malaysia has been a net exporter even when the exchange rate was at RM2.50. At the lower rate, it was calculated that exports would rise significantly and imports would fall substantially because the weaker conversion would reduce demand for foreign

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goods. As a result, a trade surplus totalling RM33.7 billion was recorded.

In the second quarter of 1999, Malaysia's GDP grew 4.1%, ending five straight quarters of contraction. The manufacturing sector grew 10.4%. The current account deficit during recent years went into a current account surplus. The foreign reserves rose substantially to RM121.22 billion (US$31.9 billion) in August 1999. The ratio of foreign reserves relative to money in circulation also rose by 50% since capital controls were initiated. The KLSE index recovered to its current level above 700 points. This may not be as high as the peak that was once attained, but foreign participation this time is minimal. This is encouraging because it is better that foreign capital enter into long-term direct investments than into speculative portfolios.

The recovery efforts became profound when the one-year moratorium on foreign investments into the KLSE expired in September 1999. Contrary to widespread expectations and fears, the exit of funds produced no significant effect on the country's strong foreign reserves. In retrospect, many observers, both local and abroad, would not have thought that the revolutionary way in which Malaysia chose to deal with its own economy would bear results. The approach defied the more conventional remedies recommended by foreign sources that are theoretically sound, but would have been devastatingly painful.

and 10%, respectively. The decline in investments occurred despite the high savings rate of 41.2%.

The 1998 figures also show that expansion in exports over imports helped ease the contraction of GDP. Exports amounted to RM282 billion, compared to RM212.7 billion worth of imports. This yielded a surplus in the merchandise balance of RM69.3 billion. After adjusting for negative services balance and transfers, there still remained a surplus on the current account, amounting to RM36.1 billion.

The weak Malaysian ringgit was a major factor that caused imports to fall. Production in Malaysia has been highly dependent on imports for intermediate components. The producer price index (PPI) surged by

10.7% in 1998, compared to only 2.7% during the previous year, while the consumer price index (CPI) increased by 5.3%, compared to 2.7% during the previous year.

The economic outlook for 1999 was more optimistic as investments and consumption were once again on the rise. The savings rate was expected to remain high, at around 40% of GDP. Estimates at the end of the first quarter of 1999 showed that private and public investments were likely to expand modestly in 1999, at around 1% and 13%, respectively. Private and public consumption was also expected to expand by about 1% and 10%, respectively. Price levels were expected to ease, with the PPI rising only by 1.5%, and the CPI rising by about 4%. These effects, and the continuing trade surplus, were expected to bring about a GDP growth of around 1% in 1999.

An overview of the Malaysia economy in 1994, 1998 and 1999 is provided in Table 2.1.

Table 2.1: Overview of the Malaysian Economy

	1994 (Official)	1998 (Preliminary)	1999 (Forecast)
Growth rate (% change / year)	9.2	–6.7	1.0
GDP (RM billion, constant price)	109.9	131.3	132.6
Savings rate (% of GNP)	36.0	41.2	40.2
Consumption (% change / year):			
Private	9.8	–12.4	1.1
Public	5.9	–3.5	10.1
Investments (% change / year):			
Private	27.9	–57.8	0.9
Public	–0.6	–10.0	12.8
Exports (RM billion current price)	148.5	282.0	277.6
Imports (RM billion, current price)	143.9	212.7	220.5
Current Account (% of GDP)	–9.4	36.1	29.5
CPI (% change / year)	3.7	5.3	4.0
PPI (% change / year)	4.0	10.7	1.5
Debt service ratio (% of exports)	4.9	5.5	6.7
Population (million)	20.1	22.2	22.7
GNP per capita (RM)	5,169.2	5,608.1	5,563.9

Source: Bank Negara Reports, 1996 & 1998

Energy Balance

Malaysia's primary energy resources are oil, gas, coal and hydropower. In 1994, oil and natural gas, combined, constituted almost 93% of the primary energy consumption, with the balance being taken up by coal and hydropower. Apart from hydropower, the contribution of renewable sources of energy to the country's energy mix is relatively small. The National Energy Balance essentially compiles commercial energy data and excludes data for biomass and other forms of energy, as data is not readily available. Recent studies undertaken by the Standards and Industrial Research Institute of Malaysia (SIRIM) and the Forest Research Institute of Malaysia (FRIM), however, estimate that the current mix is 13%. Further, in recent years, gas has been increasingly used as a source of energy input in power stations. Gas is in fact the least-cost economic energy option, as well as being a cleaner and much more efficient fuel than oil or coal. In 1994, natural gas provided 51.6% of energy input in power stations, increasing to 63% in 1997.

The total primary energy supply for 1994 was 28,247 ktoe (kilo tonne of oil equivalent), while the final demand was 19,287 ktoe. The average annual growth rates were 7.4% and 10.4%, respectively. Further, in 1994, the energy intensity of primary energy was 257 *toe*/GDP at 1978 prices (RM million), while the energy intensity for final energy was 175 *toe*/GDP at 1978 prices (RM million).

As indicated in Figures 2.4 and 2.5, Malaysia's main primary energy supply in 1994 was crude oil, contributing 48% of the total 28,247 ktoe. This was followed by natural gas (32%), petroleum products (7%), coal and coke (6%), hydropower (6%) and electricity (with less than 1% – being the difference between the import and export of electricity).

The industrial and transport sector took up a major bulk (almost 76%) of the final commercial energy demand. The final energy demand attributed to the residential and commercial sector was 13% while non-energy (mainly naphtha bitumen and lubricants obtained by the refinery process from petroleum but used for non-energy purposes) and agriculture made up the remaining 11%.

Figure 2.4 Primary Energy Supply (ktoe) in 1994

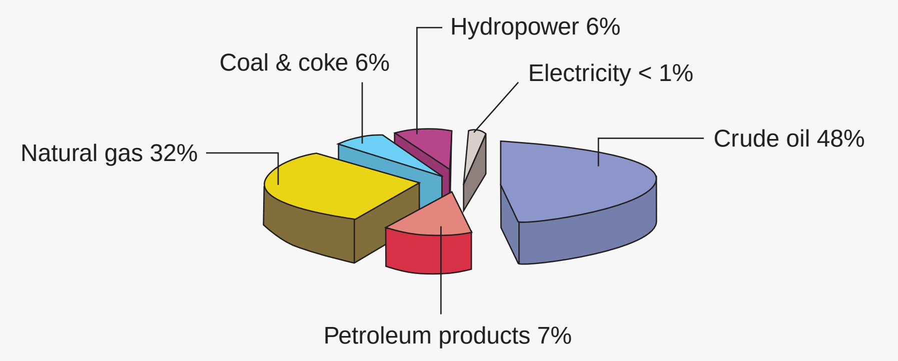
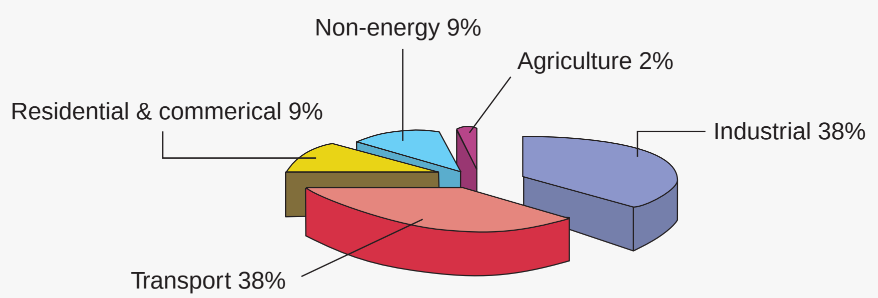


Figure 2.5 Primary Energy Demand by Sectors (ktoe) in 1994



Source: National Energy Balance 1994, MECM

Renewable Energy

Although Malaysia has a significant resource base of non-renewable energy (such as, oil, gas and coal), hydropower is also utilised, thus forming the four-fuel policy of the Government. The Government was also seriously looking at renewables as a major energy source.

In the field of renewable energy, besides hydropower, a number of projects to ascertain the potential use of biomass in the form of rice husks, fuel wood and palm oil waste to generate energy are being carried out. The Government has begun a feasibility study on power stations using biomass and co-generation technology. The study looks not only into the connection of such stations into the national power grid but also at prospects for the extraction and transfer of energy resources that are needed to feed these stations. Unwanted products from the palm oil industry are a potential fuel for which data are being assembled. Various other possibilities are also being investigated (such as the use of rice husks and wood fuel).

Two other projects are:

(i) The Development of Application and Evaluation of Biomass Energy Technologies through Briquetting of Biomass (wood and agricultural residues).

This project was carried out by FRIM in collaboration with a private company. A pilot sawdust briquetting and carbonisation plant was set up in Sarawak. It is hoped that, through this project, sufficient information to facilitate the design of a commercially viable plant can be obtained.

(ii) The Solar Photovoltaic Power Generating Project.

This project was funded through an international co-operation research and development programme between Malaysia and Japan and is an example of a case where solar electrification has been successfully implemented. The village (pop. 500) has been enjoying solar power day and night, since the photovoltaic power generating project was completed. It is the largest central photovoltaic system in the region. The 100kW peak system consists of almost 1,900 PV modules, 250 units of battery storage and an efficient power controller unit to provide AC power continuously to the people through a village Distribution Grid.

A summary of the National Circumstances is shown in Table 2.2.

Table 2.2 Summary of National Circumstances

Criteria		*1994*
Population		20,111,600
Relevant Areas (square kilometres)		329,733
GDP (at 1978 constant prices)		RM109,915 mil
(1994 US$) (at exchange rate US$1.00 = RM2.6231)		US$41,903 mil
GDP per capita (at 1978 constant prices)		RM5,465
(1994 US$)		US$2,083
Share of the industry in GDP (percentage)		32%
Share of services in GDP (percentage)		23%
Share of agriculture in GDP (percentage)		11.5%
Land area used for agricultural purposes (square kilometres)		53,904
Urban population as percentage of total population		53.8%
Livestock population	Cattle	725,000
	Buffaloes	167,000
	Goats	304,000
	Sheep	249,000
	Swine	3,203,000
	Poultry	97,423,000
Forest area (square kilometres)		190,000
Life expectancy at birth (years)	Male	69.3
	Female	74.0
Literacy rate (adult literacy)		83%

Source: Statistics Department, Malaysia.

3. Inventory of Greenhouse Gas Emissions

Methodology for Making Estimations

The national GHG inventory covers three major GHGs: carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). GHG emissions from sources and removal by sinks resulting from human (anthropogenic) activities have been estimated and included in the inventory. Natural processes lie outside the scope of the inventory. The sources and sinks were grouped under five categories, namely, energy, industrial processes, agriculture, land use change and forestry, and waste.

The compilation of the inventory involved several stages. First, data from various agencies represented under the five categories were collected and relevant emission factors assigned. The data were then analysed and the emissions of the GHGs from the respective sectors estimated. Finally, the inventory report was subjected to close scrutiny by a panel of reviewers to check the validity of the data and reporting

The preparation of GHG inventory has provided a good foundation for the development of a more comprehensive national inventory in the future. Some difficulties were encountered during data collection, especially from the forest plantation sector. This was mainly due to the difference in the database collection formats used by the relevant agencies in Peninsular Malaysia, Sarawak and Sabah.

There was also the problem associated with the categorisation of forests. As the management of forests is the responsibility of the State, there are differences in categorisation from state to state. Obtaining a set of sub-categories for the changes in forest and woody biomass stocks therefore became complicated. This problem has possibly affected the accuracy of the results.

Currently, all the emission factors used (with the exception of emissions from rice fields) were adopted wholly from the IPCC guidelines, as local emission factors were not available. This has posed some degree of concern with the results as the IPCC default values tended to address a wide area, rather than being country-specific. The emission factor for rice fields was taken from Thailand, as the types of paddy grown and the growing methods used were quite similar to those of Malaysia.

Another area of uncertainty concerned forest fires, although these do not occur frequently in the country. Forest fires create GHG fluxes within the atmosphere over extensive periods of time. Considering the fact that carbon uptake occurs with subsequent re-growth (assumed to balance out the initial carbon flux), and because emissions from natural forest fires cannot be distinguished from those from human-induced fires, estimates from this source became very difficult and were not included in the inventory.

Differences in terminology definitions also affected the compilation of the inventory. For instance, there was much ambiguity in defining afforestation, reforestation, and sink enhancement, thus resulting in some uncertainty in the emission estimates.

Emissions of CO_2, CH_4 and N_2O

Malaysia's GHG emissions totalled the equivalent of 144 million tonnes of CO_2 in 1994. Net emissions, after accounting for sinks, totalled the equivalent of 76 million tonnes. On a per capita basis, the net emissions were equivalent to 3.7 tonnes.

Table 3.1 shows the nation's emissions of the three main GHGs in 1994 on a sectoral basis. To provide an overall assessment, the various GHG emissions are also expressed as the equivalent of CO_2 emissions. In calculating CO_2 equivalents, the Global Warming Potential (GWP) index was used. Since the various GHGs have different warming effects, the GWP was developed to allow for the effect of the various GHG emissions on climate to be compared.

Applying the 1990 GWPs (100-year time frame), Table 3.2 shows the CO_2 equivalents of the three GHGs in 1994.

Table 3.1 Summary of National Greenhouse Gas Emissions and Removal in 1994

Sources & Sinks			*1994*					
			CO_2		*CH_4*		*N_2O*	
Categories			*Gg*	*%*	*Gg*	*%*	*Gg*	*%*
1.	**Energy**	Fuel combustion	84,415	86.7				
		Fugitive emissions from coal mining			0.13	0.006		
		Fugitive emissions from oil & gas systems			593	26.6		
		Burning of traditional biomass fuels			42	1.9	0.35	86.4
2.	**Industrial Process**	Cement production	4,973	5.1				
3.	**Agriculture**	Domestic livestock enteric fermentation and manure management			75	3.4		
		Flooded rice fields			252	11.3		
		Burning of agricultural residues			2.3	0.1	0.054	13.3
4.	**Waste**	Landfills			1,043	46.8		
		Domestic & commercial wastewater treatment			3.5	0.16		
		Industrial wastewater treatment	318	0.3	220	9.8		
5.	**Land Use Change and Forestry**	Changes in forest and other woody biomass stock (Sink)	–68,717	—				
		Forest and grassland conversion	7,636	7.8				
		On-site burning of forest			0.13	0.006	0.001	0.3
	Total (emission only)		97,342	100	2,231	100	0.405	100
	Net Total (after subtracting sink)		28,625					

Note: (i) (–) denotes sink
(ii) Total CO_2 emissions from international bunkers: 785.55 Gg.
(Has already been subtracted from total CO_2 emissions in the energy sector)

Table 3.2: Emissions and Removal of Greenhouse Gases for Each Sector in 1994

Sectors		*Emissions (Gg)* *A*	*GWPs* *B*	*CO_2 Equivalent (Gg)* *C= (A × B)*
Energy	CO_2 CH_4 N_2O	84,415 635 0.35	1 21 290	84,415 13,335 102
Sub-total				97,852
Industrial Processes	CO_2	4,973	1	4,973
Sub-total				4,973
Agriculture	CH_4 N_2O	329 0.054	21 290	6,909 16
Sub-total				6,925
Land Use Change and Forestry	$CO_{2(Emission)}$ $CO_{2\ (Sink)}$ CH_4 N_2O	7,636 –68,717 0.13 0.001	1 1 21 290	7,636 –68,717 3 0.3
Sub-total				7,639
Waste	CO_2 CH_4	318 1,267	1 21	318 26,607
Sub-total				26,925
Total (emissions only) Net Total (after subtracting sink)				144,314 75,597

Summary of GHG Inventory by Gas

Carbon Dioxide (CO_2)

The CO_2 emissions primarily came from the following categories: energy, industrial processes and land use change and forestry. The total emissions were 97,342 Gg in 1994. Figure 3.1 presents the contributions by the various sub-sectors.

Table 3.3 shows the CO_2 emissions from final energy use (excluding electricity) by various activities of the economy – transportation (49%), industries (41%), residential and commercial activities (7%), and agriculture (3%). It is noted that the final CO_2 emission totalling 43,768 Gg from final energy use (excluding electricity) as shown in Table 3.3 is very much less than the emission of 84,415 Gg estimated from primary energy supply as shown in Table 3.1 (Fuel Consumption). The latter

Figure 3.1: CO_2 Emissions and Sink from Various Sub-sectors in 1994

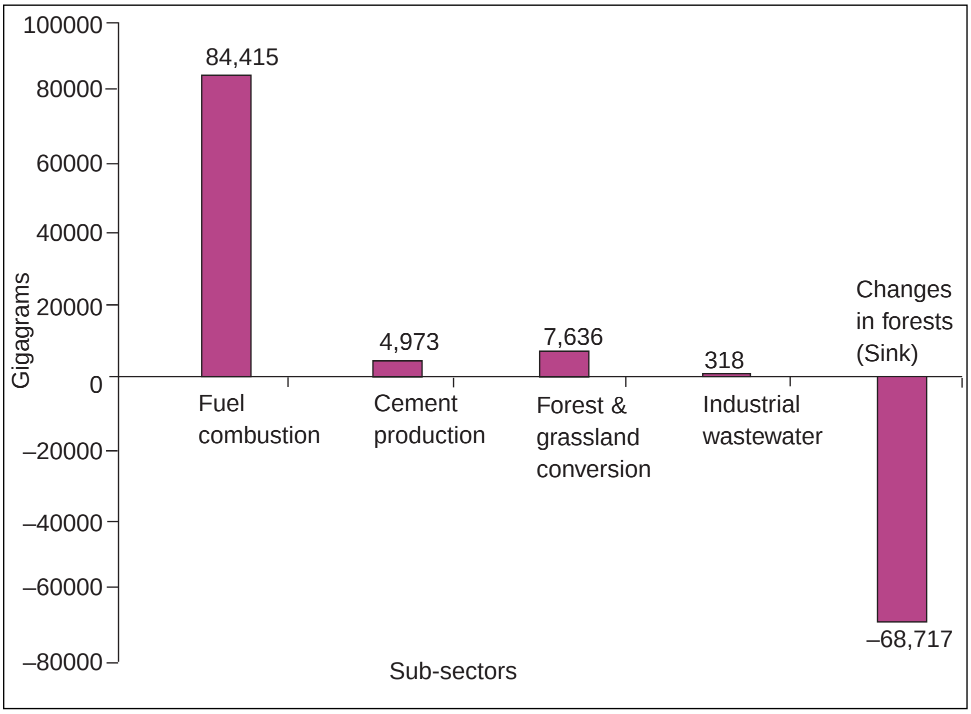


Table 3.3: CO_2 Emissions (Gg) from Fuel Combustion based on Total Final Use in 1994

	Natural Gas	*Aviation Gas*	*LPG*	*Motor Petrol*	*ATF*	*Kerosene*	*Diesel Oil*	*Fuel Oil*	*Coal & Coke*	*TOTAL*	*%*
Residential & Commercial	493	0	1,833	0	0	438	71	180	0	3,014	7
Industries	1,131	0	588	34	0	15	9,413	4,220	2,681	18,083	41
Transportation	12	14	0	11,855	2,884	0	6,549	61	0	21,375	49
Agriculture	0	0	0	0	0	0	1,293	3	0	1,296	3
TOTAL	1,636	14	2,421	11,889	2,884	453	17,326	4,464	2,681	43,768	100

Note: ATF = Aviation Turbine Fuel LPG = Liquefied Petroleum Gas

refers to the top-down or reference approach, where it is assumed that all types of fuel are consumed for energy transformation and final use. Figures 2.4 and 2.5 also demonstrate this fact. The difference between the primary energy supply and energy demand (final use) figures could be attributed to, among others, transformation to secondary supply of energy, losses incurred during transformation and transmission, and statistical discrepancies.

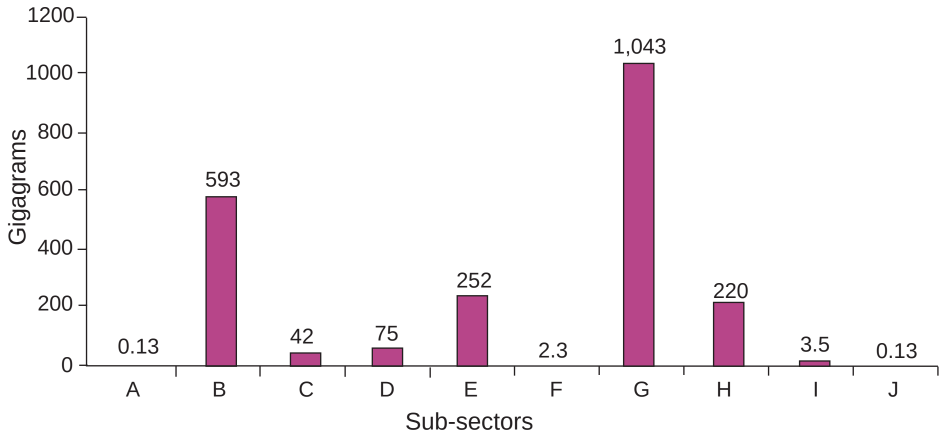
Methane (CH_4)

CH_4 emissions, which came from all the categories (except industrial processes), totalled 2,231 Gg in 1994. Figure 3.2 presents the contributions from the various sub-sectors.

Nitrous Oxide (N_2O)

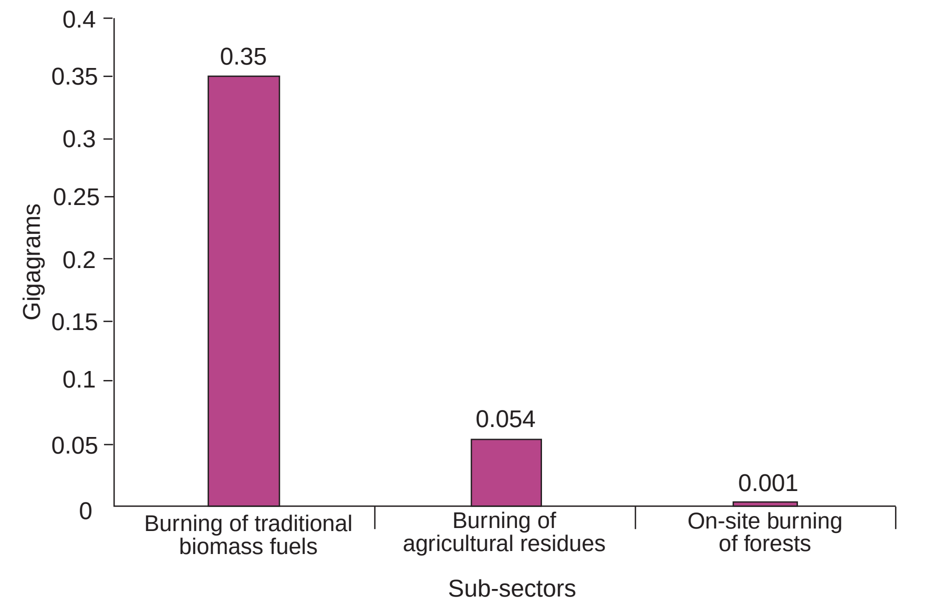
N_2O emissions were mainly from the energy, agriculture and land use change and forestry categories, and they totalled 0.405 Gg in 1994. Figure 3.3 presents the contributions by the various sub-sectors.

Figure 3.2: CH_4 Emissions from Various Sub-sectors in 1994



A Fugitive emissions from coal mining
B Fugitive emissions from oil & gas
C Burning of traditional biomass fuels
D Domestic livestock enteric fermentation & manure
E Flooded rice fields
F Burning of agricultural residues
G Landfills
H Industrial wastewater
I Domestic & commercial wastewater treatment
J On-site burning of forests

Figure 3.3: N_2O Emissions from Various Sub-sectors in 1994



Summary of GHG Inventory by Sector

Energy

The GHG emissions from the energy category are from fuel combustion, fugitive emissions from coal mining, fugitive emissions from oil and gas systems, and the burning of traditional biomass fuels. In 1994, fuel combustion released mainly CO_2, which totalled 84,415 Gg. The other three sectors released primarily CH_4, with the highest contributions of 593 Gg coming from fugitive emissions from oil and gas systems. A small amount of N_2O (0.35 Gg) was also released through the burning of traditional biomass fuels.

Industrial Processes

The emission of GHGs from industrial processes is not from energy-related activities, but from the production process. The type of GHG emitted depends on the nature of the manufacturing process. In this inventory, the major contribution is from cement production, which released 4,973 Gg of CO_2 in 1994.

Agriculture

The various sub-sectors in the agriculture category release mainly CH_4, with a small amount of N_2O. In 1994, flooded rice fields accounted for 252 Gg of CH_4 emissions and 0.054 Gg of N_2O emissions from burning of agricultural residues.

Waste

Solid waste and wastewater produce CH_4 under anaerobic conditions. In 1994, most of the 1,043 Gg of CH_4 emissions came from landfills, 220 Gg from industrial wastewater treatment, and 3.5 Gg from domestic and commercial wastewater treatment.

Land Use Change and Forestry

Land use change and forestry involve both the emission and sink of GHGs. In 1994, emissions of CO_2 came mainly from the conversion of forests and grassland. These totalled 7,636 Gg. On-site burning of forests released 0.132 Gg of CH_4 and 0.001 Gg of N_2O. Changes in forest and other woody biomass stock resulted in a net CO_2 sink of 68,717 Gg.

Comparison of Malaysia's GHG Emissions with Selected Countries

From the inventory exercise, it was observed that Malaysia's GHG emissions were relatively small. Table 3.4 shows how Malaysia fared in its GHG emissions when compared with some selected countries.

Table 3.5 shows how Malaysia compares with several other countries in the amount of CO_2 emissions per capita from fuel combustion, based on a recent report by the International Energy Agency.

Table 3.4: GHG Emissions of Selected Countries

Country	*Year*	*GHG emissions (million tonnes)*
Malaysia	1990 1994	138.0 144.0
Thailand	1990	225.0
Australia	1990	572.0
Japan	1990 1994	1,215.9 1,276.1
USA	1990 1994	5,895.9 6,130.8

Note: The emissions are expressed as CO_2 equivalents, and include the major GHGs (CO_2, CH_4 and N_2O)

Table 3.5: CO_2 Emissions per Capita from Fuel Combustion of Selected Countries (1996)

Country	*Tonnes CO_2/Capita*
Philippines	0.91
Indonesia	1.21
Thailand	2.92
Malaysia	**5.13**
Japan	9.36
United Kingdom	9.91
Australia	10.57
Canada	15.67
United States	20.05
Singapore	21.45
Brunei	27.92

Projection of GHG Emissions

The bulk of the CO_2 emissions came from the energy sector, accounting for 87% of the total emissions. Since it is in the energy sector that a fair amount of work has been done on its demand and supply outlook, this projection exercise focused on the CO_2 emissions from that sector. Projections from the other sectors, as well as for the other GHGs, could not be carried out due to the unavailability of reliable projected base data.

The energy outlook for Malaysia has been drawn up as part of only one plausible economic scenario, based on a revision of projections made by the Economic Planning Unit (EPU) in late 1991. In view of the concerted government efforts to ensure that Vision 2020 targets are achieved, the single targeted growth economic projection is adequate for this exercise. The economy is expected to expand almost eight-fold from 1990 to 2020.

As population is not a dynamic variable, a single population projection is made. Total population is expected to increase from 17.8 million in 1990 to 32 million in 2020, implying annual average growth rates of about 2.0% in the period 1990–2020. The annual growth rate is expected to decline from 2.4% in the period 1995–2000 to 1.5% in 2010–2020.

In carrying out the projection exercise, pertinent information was extracted from a country study on efficiency-oriented and environmentally-constrained alternative energy strategy scenarios (EASES). For the energy futures, two plausible scenarios are considered:

1. Business-As-Usual (BAU) scenario to reflect continued market trends without any serious attempts to improve energy efficiency in the Malaysian economy; and

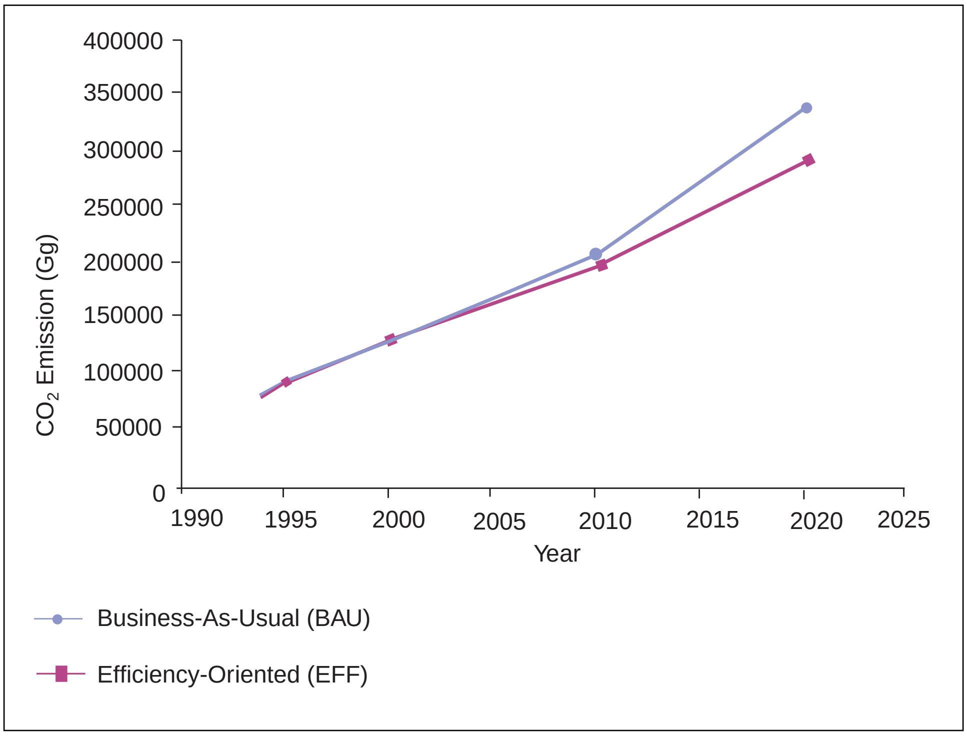
2. Efficiency-Oriented (EFF) scenario with greater emphasis on energy efficiency improvements to reflect better marketing in increasing adoption of proven latest technologies. Efficiency gains in electricity consumption are assumed to reach 1% in 2000, 10% in 2010 and 20% in 2020, while gains for non-electricity consumption are only 5% in 2010 and 10% in 2020.

The forecast in CO_2 emissions from the energy sector for these two scenarios is shown in Table 3.6 and Figure 3.4. Essentially, the CO_2 emissions are from the primary energy supply consisting of coal, oil and gas. As expected from the results obtained, the projected CO_2 emissions are markedly higher in the BAU scenario compared to the EFF scenario.

Table 3.6: Projected CO_2 Emission by Scenario, 2000–2020

	Actual (Gg)		*Projected (Gg)*		
	1994	*1995*	*2000*	*2010*	*2020*
Business-As-Usual (BAU)	84,415.25	95,235.75	132,990	211,662	341,491
Efficiency-Oriented (EFF)	84,415.25	95,235.75	132,561	198,315	294,470

Figure 3.4: Projected CO_2 Emissions by Scenario, 2000–2020



It must be noted that any long-term projections based on some key assumptions should only be used as a reference for discussion of trends. Many special factors make the modelling of energy trends, and hence CO_2 emissions, especially difficult and the derived projections uncertain.

Reducing emissions with the introduction of state-of-the-art light rail transit system in Kuala Lumpur

4. Environmental and Sustainable Resource Management

Sustainable Development Goals

As a developing country, Malaysia has endeavoured, since the 1970s, to introduce a variety of regulatory and non-regulatory measures in order to balance the goals of socio-economic development and the maintenance of sound environmental conditions. These objectives were then spelt out in the Third Malaysia Development Plan (1976–1980), and have been reaffirmed in the subsequent development plans of Malaysia. The essential elements are also embodied in all short-, medium- and long-term national policies and plans, namely, the Second Outline Perspective Plan (OPP-2) (1991–2000), as well as Vision 2020. A draft National Policy on the Environment has also been prepared, which is currently under consideration by the Government, re-emphasising the principles and practices of long-term environmentally sound and sustainable development.

Malaysia's pursuit of rapid economic growth is complemented by a deep sense of the need to achieve a clean and healthy environment as part of the overall objectives of development. In this connection, pursuing sustainable development, promoting environmentally sound technologies via economic and legislative mechanisms, promoting conservation goals and greater environmental awareness to increase social responsibility are all integral to the planning and development efforts of the nation, at federal, state and local levels. Towards this end, the nation's unique natural resource and diverse cultural heritage do offer huge opportunities.

The Malaysian Government has also, for many years, carefully managed various aspects of the environment as a central part of its efforts to maintain and improve environmental quality. Various strategies have been introduced over the years to promote energy efficiency, control pollution, and enhance the quality of the environment. These include the introduction of energy efficiency

Sustainable development for a vibrant economy. Modern light rail transit supplements vehicular transport in downtown Kuala Lumpur.

guidelines for buildings, improvement of road systems, construction of light rail transit and electric rail systems, promulgation of pollution control laws and their enforcement, land use planning and increasing public awareness.

Environmental and Related Legislation

The main environmental legislation in Malaysia is the Environmental Quality Act (EQA) 1974 (amended in 1985 and 1995), which provides for the control and prevention of pollution, as well as the protection and enhancement of environmental quality of all segments of the environment, including air, water and land. There are also more specific sectoral legislations. For example, the Electricity Supply Act 1990 regulates electricity generation and utilisation, the Petroleum Mining Act 1972 covers the management of all oil and gas reserves, the

Road Transport Act 1987 controls the use of different types of motor vehicles, while the Occupational Safety and Health Act 1994 regulates, among others, the use of all equipment in working areas. Other relevant legislation include the National Forestry Act 1984 (amended 1993) for the management of forestry resources, as well as other natural resource management legislation on matters such as water, mining, and fisheries.

Environmental Monitoring and Surveillance

In Malaysia, increases in the level of compliance with environmental standards, as well as reductions in the number of violations, have been the result of combined monitoring and enforcement efforts by a variety of government agencies.

Business councils, environmental groups, scientific research and development institutions, as well as the mass media, are also promoting the concept of sustainable development, the use of clean technologies and pollution control equipment. Property developers, especially those associated with housing and commercial construction, are being mandated by local authorities to create greener environments by planting trees as part of environmentally sound practices.

Monitoring water quality, with a view to protecting the nation's water resources, has also been an important part of the environmental management initiatives by the Government. Between 1991 and 1995, the number of rivers monitored for water quality in the country increased from 87 to 119. Among the 119 rivers monitored in 1995, 48 were found to be clean, 53 slightly polluted and 14 highly polluted. Sewerage facilities of 143 local authority areas were privatised in 1993 in order to improve these services with a view to reducing river pollution from domestic sources.

Limited air quality monitoring has been carried out since 1975. With the privatisation of the ambient air quality monitoring in 1996, a very extensive network and comprehensive parameters have been established.

Lands scarred by tin mining activities (top) are being rehabilitated to wetland sanctuaries (middle) and water recreational parks (bottom)

The need to manage waste properly is also one of Malaysia's environmental challenges. A survey of selected Local Authority Areas estimated that the urban population generated some 3.93 million tonnes of solid waste in 1993, or 0.74 kg per person per day. Landfills and municipal dumping grounds have to be carefully managed and closely monitored. Further, wastes classified as being hazardous or toxic warrant special attention.

In keeping with the Government's efforts, a code of practice has also been established, alongside comprehensive legislation governing the use, storage, handling, transport, labelling and disposal of toxic and hazardous wastes. Some 337,000 tonnes of waste generated in the country fell in this category in 1992. To handle such wastes, a centralised integrated facility for the collection, storage, treatment and disposal of toxic and hazardous wastes in Bukit Nanas, Negeri Sembilan was commissioned by the Government and launched in November 1998. A network of waste transfer stations located in Pulau Pinang, Johor and Terengganu supplements this facility.

In agriculture, particularly in the plantation sector, efforts to reduce air pollution from open burning have been successful through the adoption of zero-burning practices. These efforts have been further strengthened by the DOE's recent stepped-up enforcement on open burning in various sectors.

While Malaysia's efforts at phasing out CFCs under the Montreal Protocol have been exemplary, there are no specific laws yet to control the emission of other GHGs. Emissions from vehicles, industries and power generators remain the main sources of air pollution. The Environmental Quality (Clean Air) Regulations 1978 has provisions to limit emissions from motor vehicles except for motorcycles which account for more than half of the 8.5 million registered vehicles in the country in 1998.

Managing Natural Resources

In order to achieve a higher quality of life for Malaysians through sustainable development, the Government has adopted an integrated approach towards attaining both environmental and developmental objectives. Some of the strategies being continuously adopted and promoted for natural resource management are:

- The prevention and control of pollution and other forms of environmental degradation, through the screening of proposed development projects by adopting the precautionary and polluter pays principles;
- Land-use planning based on land suitability, land capability and carrying capacity, as well as the current and future needs of the community; and
- Integrated project planning and implementation, whereby environmental considerations are given emphasis.

Projects that may have significant impacts on the environment would be required to undergo mandatory Environmental Impact Assessment

Verdant green forest in Ampang, adjacent to the city of Kuala Lumpur

International visitors on a tour of the man-made Wetlands Park in Putra Jaya, the new Federal Government administrative centre

(EIA), prior to project implementation. Further, ecosystems and habitats – such as forests, wetlands, water catchment areas and coastal zones – are sustainably managed in order to ensure protection of their inherent benefits and compatibility with environmental stability and ecological balance.

There is extensive consultation and negotiation between the Federal and State Governments in the promulgation and implementation of policies and strategies for natural resource management.

Several measures have been taken to improve land use planning and to further reduce negative impacts stemming from land development, such as, erosion and landslips. The Town and Country Planning Act 1976 was amended in 1994 to require that municipal structure plans and local plans for development projects incorporate conservation measures.

Malaysia's forestry resource is protected in areas delineated as Permanent Forest Reserves (PFR), as spelt out in the 1978 National Forestry Policy. By 1995, a total of 14 million hectares have been gazetted under the PFR category. In 1994, forests covered 58% of the country's total land area. With the addition of tree crops, the tree cover increased to 72%.

The Government has decided on a long-term commitment to maintain a minimum of 50% forest cover. To ensure the successful achievement of its forestry goals, the National Forestry Act of 1984 was amended in 1993 to further strengthen enforcement. The driving principle was to ensure the natural regeneration of forests, while producing a sustained supply of timber and clean water, and ensuring ecological stability and the maintenance of biodiversity.

The Malaysian Uniform System (MUS) and the Selective Management System (SMS) are both being adopted for managing forest resources. The country is also gearing itself to meet its commitments under the International Tropical Timber Organisation (ITTO) objective of ensuring that tropical timber that is to be traded by the year 2000 comes only from forests that are sustainably managed.

Malaysia has been recognised as one of the 12 mega biodiversity countries in the world. To sustainably manage its rich and diverse natural heritage, the Government has established several national and marine parks, wildlife reserves, sanctuaries and PFRs under several Federal and State legislations.

Malaysia ratified the Convention on Biological Diversity in 1994. Since issues pertaining to biodiversity are cross sectoral, a National Committee on Biological Diversity, with representation from various agencies, was set up under the chairmanship of MOSTE to oversee the implementation of the Convention and also to address national issues. A National Policy on Biological Diversity was launched in April 1998. This policy aims to conserve, manage and promote the sustainable utilisation of biological resources. Malaysia is also a party to the Convention on Wetlands of International Importance especially as Waterfowl Habitat (Ramsar Convention) and has designated a wetland ecosystem in the State of Pahang known as Tasek Bera as Malaysia's first Ramsar site.

Following the review of various legislations, several amendments have been made to address the problems related to soil erosion, air pollution and water pollution brought about by the indiscriminate clearing of land for development. The Street, Drainage and Building Act 1974 has since been amended to require that suitable soil erosion and sedimentation measures be taken. The Schedule of Works and Payment under the Housing Developers Act is currently undergoing amendment towards meeting the same goal. The existing Guidelines for the Management of Land to Control Soil Erosion and Siltation are being reviewed, while a Soil Conservation and Sedimentation Act is also being considered.

To protect coastal and marine resources, a National Coastal Zone Management Policy is being formulated to provide the basic principles and guidelines for addressing conflicts and other relevant environmental considerations arising from different types of development at coastal locations. Integrated Coastal Zone Management (ICZM) plans are being drawn up to co-ordinate development at the federal, state and local levels. To oversee the proper development of offshore islands, a National Islands Development Board is also being established.

Conservation of the nation's energy sources and mineral resources involves limiting the production of oil to 630,000 barrels a day, besides setting a gas consumption limit of 2,000 million standard cubic feet a day. In 1992, the National Mineral Policy was introduced, leading to the 1994 Mineral Development Act. The legislation has several aims, including optimising mineral exploitation, minimising wastage, increasing exploration, upgrading technologies, mitigating negative environmental impacts and rehabilitating former mining land for alternative uses.

Other Initiatives

There have been many investigations over the years into the implications of climate change for the country's livelihood. As Malaysia is concerned about the adverse impacts of climate change, it participated in a UNEP regional study (1988–1990) on socio-economic impacts and policy responses resulting from climate change in Southeast Asia. A number of site-specific reports were prepared. These include reports on the impacts of climate change in the Kelantan river basin, impacts of climate change on rice production in the Muda Scheme area of Kedah, effects of rainfall and soil drainage on oil-palm yield performance in the coastal region basin, and impacts of sea-level rise on agricultural development projects in West Johore. This was one of the earliest studies conducted in a developing country at that time. In addition, a Malaysian country study on Climate Change in Asia, sponsored by the Asian Development Bank, was completed in 1994.

Further, a study on agrometeorology was carried out in 1991 by the Malaysian Meteorological Service, in collaboration with the World Meteorological Organisation, in an attempt to address the impacts of climate change on agriculture in Malaysia.

In 1998, the Selangor State Government commissioned a study to develop a sustainable development strategy and action plan based on the Agenda 21 format. The on-going study, initiated by the Selangor Town and Country Planning Department, involves scientists from the Institute for Environment and Development (LESTARI) of Universiti Kebangsaan Malaysia (UKM). Results from this study are expected to provide insights into how best to achieve sustainable development objectives in future municipal structural plans across the country. The study will take about three years to complete, at the end of which two local authority areas will be selected to implement the local development plan based on the Agenda 21 principles and policies.

Over the next two years, a demonstration project in Kota Kinabalu, Sabah would be initiated to create a much more comprehensive urban management system which incorporates integrated waste management, sustainable environmental landuse planning, proper resource management and increasing environmental awareness among the public.

In 1999, the Malaysia Energy Centre was set to implement a four-year UNDP-GEF project entitled the Malaysia Industrial Energy Efficiency Improvement Project (IEEIP) to remove barriers to energy efficiency and energy conservation (EE&EC) in the Malaysian industrial sector. These barriers have resulted in inefficient and wasteful use of energy in industrial facilities and contributed to higher energy consumption leading to increased GHG emissions from Malaysian industries. They include:

- Limited knowledge/awareness about EE&EC techniques/technologies in industries and the lifecycle economic benefits thereof. Producers remain extremely cautious with regard to the relatively high first cost to be paid for energy-efficient equipment.

- Limited access to information on EE&EC techniques/technologies and lack of information on sectoral energy benchmarks.

- Emphasis on production-related improvements as opposed to matters related to energy efficiency.

- Lack of ready financiers for EE&EC investments.

- Limited regulations on energy efficiency standards and implementation.

- Limited EE&EC technology demonstration projects or programmes.

- Weak local energy support services. Lack of trained industry and financial sector personnel on energy management.

The beneficiaries of this Malaysia IEEIP project include government agencies and participating research organisations, industries, energy service companies, equipment manufacturers and financial institutions. This project will also contribute to competitiveness of the Malaysian economy by improving efficiency of industries.

The Government has also embarked on the task of developing appropriate sustainable development indicators (SDI) to strengthen the empirical base for decision making. This initiative will provide a platform for improved planning of resource and environmental policies, better collection of physical and environmental data and the development of appropriate conceptual analytical frameworks. Taken together, the environmental and resource data collected, and the SDI system, will provide feedback on how well the environment and resources are being managed, and help steer the nation onto the path of sustainable development.

The EPU in the Prime Minister's Department is developing Malaysian urban quality of life indicators (MUQLI). There are 10 main areas of concern in the project: health, housing, environment, income, public safety, transport and communications, education, culture, leisure and family. There are also plans to use such indicators for compiling state of the city reports across the country.

The development of indicators is also being attempted under the Sustainable Penang Initiative (SPI), conducted by the Penang State Government through its Socio-economic and Environmental Research Institute (SERI). The indicators are intended to help in assessing and monitoring the direction of economic development in relation to social well-being and environmental health. An integral part of the initiative is to mobilise public participation in the planning and development process so that the ensuing policies and actions correspond with people's aspirations and desires. Increasingly, development will have to take into account the impending effects of climate change. Efforts such as the SPI will not only provide useful indications of economic, social and environmental changes that have occurred, but will also demonstrate how community efforts can be effectively organised to produce the desired responses.

The Ministry of Health, in collaboration with the World Health Organisation (WHO), initiated a healthy cities project in 1994. Two cities in Malaysia, Johor Bahru and Kuching, were selected for the project. The aim of the project was to continually improve the physical and social environment by expanding community resources and garnering mutual support among the people. In many respects, the healthy cities project is similar to the SPI, except that it is much more focused on public health issues. The project compiled health profiles and indicators, organised workshops to create awareness about healthy lifestyles, mobilised community participation from within the city, and created channels for networking.

Non-governmental organisations (NGOs) have also been active in promoting sustainable development projects and concepts. The Environmental Protection Society of Malaysia (EPSM) has recently begun to work actively in implementing Local Agenda 21 concepts among various stakeholders. The Centre for Environment, Technology and Development Malaysia (CETDEM) did a pioneering study on renewable energy in 1994, and has been at the forefront in promoting organic farming as a viable alternative to conventional types of farming in the country. The Environmental Research and Management Association of Malaysia (ENSEARCH) has been providing training in a variety of environmental areas. More recently, ENSEARCH has expanded its focus to ISO 14000 related issues. The Centre for Environmental Technologies has been concentrating on issues involving the reduction of ozone-depleting substances and cleaner production technologies. Friends of the Earth Malaysia (Sahabat Alam Malaysia) has been active in lobbying and raising public awareness over a wide range of environmental issues. The Malaysian Nature Society (MNS) and the World Wide Fund for Nature, Malaysia (WWFM) have been generally undertaking projects on the conservation of natural resources and increasing public awareness on selected environmental issues.

In addition to the above activities, SIRIM, for example, has initiated a cleaner technology programme, as well as the establishment of a Cleaner Technology Extension Service. As a proactive measure on the part of the private sector, the Business Council for Sustainable Development in Malaysia was established in 1992 to solicit and foster the active participation of the business and industrial community in caring for the environment. Other organisations – such as, the Federation of Malaysian Manufacturers (FMM) and the Malaysian International Chamber of Commerce and Industry (MICCI) – also encourage their members to include environment considerations in corporate operations.

Multilateral Efforts

The Malaysian Government has undertaken several initiatives to pursue environmental goals and sustainable development objectives at the multilateral level. During the Commonwealth Heads of Government Meeting (CHOGM) in 1989, Malaysia initiated the Langkawi Declaration on Environment which was unanimously adopted by the Commonwealth. The principal features of the Langkawi Declaration include supporting the work of IPCC, calling for the early conclusion of an international convention to protect the global climate, supporting the findings and recommendations of the Commonwealth Expert Group on climate change as a basis for strategies and actions to reduce GHG emissions, supporting measures identified for conserving and using energy efficiently, reducing and eventually phasing out ozone-depleting substances, and promoting afforestation projects and agricultural practices designed to reduce atmospheric CO_2 and to protect land and water resources.

Malaysia also played an active role in the landmark United Nations Conference on Environment and Development (UNCED). Prior to the UNCED Summit held in Rio in June 1992, the Second Ministerial Conference of Developing Countries on Environment and Development, hosted by Malaysia, resulted in the Kuala Lumpur Declaration in April 1992. Malaysia then went to UNCED with an initiative entitled Greening of the Earth, which declared Malaysia's commitment to maintain a 50% forest cover and urged world governments to undertake similar initiatives.

Besides UNCED, Malaysia has also participated actively in negotiations leading to the adoption and implementation of several international environmental conventions, including the Basel Convention on Toxic Wastes, the Montreal Protocol on Ozone-Depleting Substances, the UN Convention on Biological Diversity (UNCBD), and the UNFCCC.

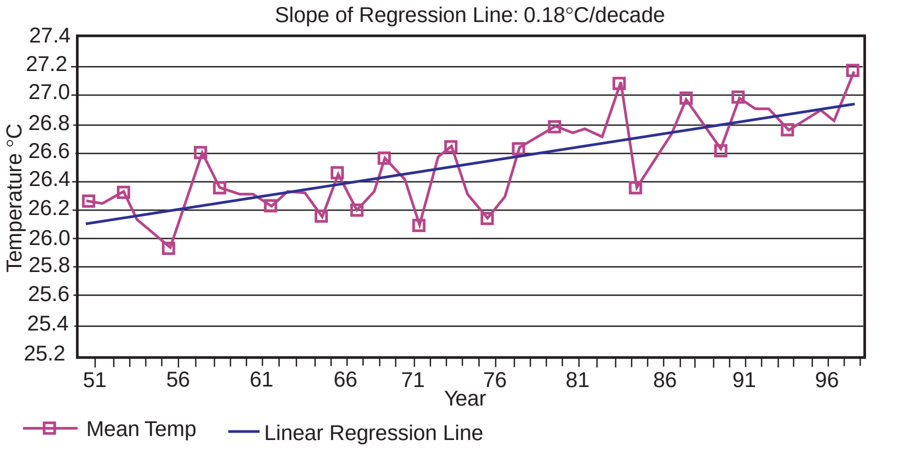
Malaysia supports the global partnership in addressing common issues under the spirit of common, but differentiated, responsibilities. It looks upon developed countries to take the lead in reducing their emissions, providing financial resources and facilitating transfer of technologies.

5. Impact of Climate Change

Temperature records in the past 30 to 50 years have shown warming trends in most places. The global mean surface temperature in the last decade has been the warmest since instrumental records began in 1860. The global mean surface temperature in 1998 exceeded that of 1997 and is the highest on record since 1860. The warming has not, however, been uniform globally, with some areas recording cooling in recent decades. An analysis of temperature records in Malaysia has also shown warming trends (see Figure 5.1).

Climate change may bring about an increase in the frequency and intensity of extreme weather events, such as, droughts, storms and floods. There is still, however, insufficient data to determine whether the frequency of extreme events has indeed increased. It has been observed that, since 1977, there have been more frequent El Nino Southern Oscillation (ENSO) warm phase episodes. This behaviour, especially the persistent warm phase from 1990 to mid-1995, was unusual in the last 120 years and significantly influenced rainfall in Malaysia.

Figure 5.1: Time Series of Mean Annual Temperature



Source: MMS

Climate Change Projections

Coupled atmosphere-ocean Global Climate Models (GCMs) are the best tools for estimating the effect of increased concentrations of GHGs. Using IS92a–IS92f scenarios, IPCC (1995) projects an increase in temperature, relative to the present, of between 1°C and 4.5°C by the year 2100. When the effect of aerosols is included, a lower range of global temperature change of 1°C to 3.5°C is projected.

The GCMs also project higher global precipitation under increased GHG concentrations. The increase is largest in the high latitudes during winter, very often extending into the mid-latitudes. The precipitation pattern in the tropics, however, differs between models, and there are shifts and changes in the rainfall maxima.

Global warming will cause the ocean to expand, thus increasing sea level. IPCC projects that sea level will rise between 13 and 94 cm in the next 100 years, taking into account model uncertainties and the extreme range of projections under all emission rates.

Using 14 selected GCMs, changes in temperature and precipitation in Malaysia under a $2 \times CO_2$ atmosphere are obtained. There is no consistent relationship between changes in temperature and changes in precipitation. The temperature changes range from +0.7°C to +2.6°C, while precipitation changes range from –30% to +30%. Analysis of the results from the models shows that the climate scenarios vary greatly from model to model, and there is no consistency in the outputs of the models.

In view of the large uncertainties and low confidence of the model outputs for regional-scale climate scenarios, a range of values for different meteorological parameters were used to assess the impacts of climate change in Malaysia. Table 5.1, which is based on the projections of future climate by regional models of Southeast Asia found in Climate Change 1995 of IPCC, shows the range of values used for the impact studies. A sea level rise of 15–95 cm in 100 years is adopted for the assessment of the impact of sea level rise on coastal resources.

Based on these scenarios, the impacts of climate change on key economic sectors – such as, agriculture, forestry, water resources, coastal resources, energy and public health – are assessed.

Table 5.1: Climate Change Scenarios for Malaysia

Northern Hemisphere Summer			
Year	*2020*	*2040*	*2060*
Changes in Temperature Changes in Rainfall	+0.3 to +1.4°C –0.4 to +14%	+0.4 to +2.4°C –0.7 to +23%	+0.6 to +3.4°C –1.0 to +32.0%
Northern Hemisphere Winter			
Changes in Temperature Changes in Rainfall	+0.4 to +1.9°C –4.0 to +7.0%	+0.7 to +3.2°C –7.0 to +12.0%	+1.0 to +4.5°C –10.0 to +17.0%

Agriculture

Climate plays a major role in determining crop performance. Within a climatic zone, the weather, as expressed by the amount of rainfall, sunshine hours, temperature, relative humidity and length of the drought period, results in year-to-year variability of crop production.

The primary concern related to climate change is the potential threat it poses to national food security and export earnings from plantation crops. Any unfavourable climate change can have a negative impact on crops, animal husbandry and aquaculture.

Only key economic crops – such as, rubber, oil palm, cocoa, rice, and agroforestry – are discussed here. Animal husbandry, vegetable production, floriculture and aquaculture are mentioned briefly.

Rubber

Rubber (*Hevea*) flourishes in a tropical climate, with a high mean daily air temperature of between 25°C and 28°C, and high rainfall exceeding 2,000 mm/year. Even distribution of rainfall with no dry seasons exceeding one month and at least 2,100 hours of sunshine per year are ideal conditions for growing rubber.

The following impacts of climate change on rubber are expected:

- If the mean daily air temperature increases by 4.5°C above the mean annual temperature, more dry months and hence more moisture stress can occur. A crop decrease of 3% to 15% due to drought conditions is projected if mean annual temperature increases to 31°C. The degree of yield decrease will be dependent on clonal susceptibility, as well as the length and severity of the drought.

- Based on this climate change scenario, the states of Perlis, parts of Kedah, Kelantan and Terengganu may experience a reduction in crop production. It is projected that 273,000 ha of land, or 15% of current rubber land, may be affected. With the availability of higher yielding clones and improved cultural practices, this impact, however, may be minimised.

- If rainfall increases, loss of tapping days and crop washout will occur. As a result, yield losses can range from 13% to 30%. Thus, if the number of rain-days were to increase, then most parts of the country, particularly in the states of Terengganu and Kelantan, will suffer from rainfall interference with tapping.

- If sea level rises by one metre, low lying areas may be flooded. Rubber cultivation in these areas would be unsuitable.

Table 5.2 shows the projected rubber yield in relation to climate change over time.

Oil Palm

Oil palm (*Elaeis guineensis*) is best suited to a humid tropical climate in which rain occurs mostly at night and days are bright and sunny. For optimum yield, minimum monthly rainfall required is around 1,500 mm with absence of dry seasons, and an evenly distributed sunshine exceeding 2,000 hours per year. A mean maximum temperature of about 29°C to 33°C and a mean minimum temperature of 22°C to 24°C favour the highest bunch production.

Table 5.2: Projected Rubber Yield with Climate Change

Year	*2020*			*2040*				*2060*			
CO_2 (ppm)	*400*	*400*	*400*	*CO_2 (ppm)*	*600*	*600*	*600*	*CO_2 (ppm)*	*800*	*800*	*800*
Temp. increase °C	*0.3*	*0.85*	*1.4*	*Temp. increase °C*	*0.4*	*1.4*	*2.4*	*Temp. increase °C*	*0.6*	*2*	*3.4*
Rainfall Change (%)				Rainfall Change (%)				Rainfall Change(%)			
+14%	1.26	1.26	1.23	23%	1.42	1.42	1.42	32%	1.40	1.40	1.40
+7%	1.44	1.44	1.42	11%	1.53	1.53	1.53	15%	1.58	1.58	1.58
+0.40%	1.60	1.60	1.60	0.70%	1.80	1.80	1.80	1%	2.00	2.00	2.00
0%	1.60	1.60	1.60	0%	1.80	1.80	1.80	0%	2.00	2.00	2.00
–0.40%	1.60	1.60	1.60	–0.70%	1.80	1.80	1.80	–1%	2.00	2.00	1.82
–-7%	1.55	1.55	1.54	–11%	1.69	1.69	1.69	–15%	1.80	1.78	1.72
–14%	1.46	1.46	1.44	–23%	1.53	1.53	1.49	–32%	1.60	1.60	1.52

Note:
1. Yield expressed in tonnes / ha / yr
2. Yields are projected based on direct effects of climatic features only. Other interactive features such as the effect of climate on disease incidence, length of wintering period etc. are not considered

Climate change may affect oil palm cultivation as follows:

- A higher mean annual temperature of 28°C to 31°C is favourable for high fruit production. If these higher temperatures lead to drought conditions, however, an estimated 208,000 ha of land, or 12% of the present oil palm areas, would be considered marginal-to-unsuitable for oil palm cultivation. Drought-prone areas in parts of Kelantan, Terengganu, Pahang, Johore, Kedah, Perak, Negeri Sembilan and Melaka are, therefore, most vulnerable.

- Increased rainfall favours oil palm productivity unless it leads to flooding. With an anticipated sea level rise of 1 metre, an estimated 100,000 ha of area, currently planted with oil palm, may be deemed unsuitable and would have to be abandoned.

Table 5.3 shows the projected oil palm yield in relation to climate change. It can be seen that a decrease in rainfall affects yield significantly.

Table 5.3: Projected Oil Palm Yield with Climate Change

Year	*2020*			*2040*				*2060*			
CO_2 (ppm)	*400*	*400*	*400*	*CO_2 (ppm)*	*600*	*600*	*600*	*CO_2 (ppm)*	*800*	*800*	*800*
Temp. increase °C	*0.3*	*0.85*	*1.4*	*Temp. increase °C*	*0.4*	*1.4*	*2.4*	*Temp. increase °C*	*0.6*	*2*	*3.4*
Rainfall Change (%)				Rainfall Change (%)				Rainfall Change(%)			
14%	21.5	21.5	22.0	23%	24.0	24.0	24.0	32%	26.0	26.0	26.0
7%	23.0	23.0	23.25	11%	25.0	25.0	25.0	15%	27.0	27.0	26.0
0.40%	22.5	22.5	22.75	0.70%	24.5	24.5	24.5	1%	26.0	26.0	25.0
0	22.0	22.0	22.0	0%	24.0	24.0	24.0	0%	26.0	26.0	26.0
–0.40%	22.0	22.0	22.0	–0.70%	23.5	23.5	23.0	–1%	24.0	24.0	22.0
–7%	17.6	17.6	17.0	–11%	19.2	19.2	18.7	–15%	18.0	18.0	15.6
–14%	15.4	15.4	15.4	–23%	15.6	15.6	14.9	–32%	14.3	14.3	13.0

Note: Yield expressed in tonnes/ha/yr

Cocoa

Although cocoa (*Theobroma*) is planted in areas where annual rainfall is in the range of 1,250 to 2,800 mm, it prefers areas where annual rainfall is 1,500 to 2,000 mm and the number of dry months is three or less. It should not be planted in areas with annual rainfall below 1,250 mm unless irrigation is provided. Areas with annual rainfall exceeding 2,500 mm are also not favoured as it reduces yield by 10% to 20% due to water logging. Besides, the excessive rainfall causes high disease incidence, especially *Phytophthora* and pink diseases.

Most of the cocoa growing areas have maximum temperature ranges of 30°C to 32°C and minimum temperatures of 18°C to 21°C. The temperature in Malaysia is within this range throughout the year. Temperatures exceeding 32°C may result in moisture stress leading to yield loss of 10% to 20%.

Based on these considerations, the states of Kedah, Kelantan, Perlis, Terengganu and (parts of) North Pahang that experience a distinct dry season are marginal areas for cocoa cultivation. Irrigation is required in these areas if cocoa is to be cultivated.

Some areas, which register high rainfall, such as, Sandakan in Sabah and Kuching in Sarawak, are not suited for cocoa cultivation due to the high incidence of diseases. This can result in yield loss of more than 20%.

With climate change, a higher incidence of drought is expected to reduce yield. On the other hand, excessive rainfall with reduced insolation can also result in low yields. In addition, under such weather conditions, a high incidence of fungal diseases – such as, vascular streak disease and black pod – can depress yields.

Table 5.4 shows that cocoa yield is sensitive to both excessive and reduced rainfall. In both cases, the yield is decreased.

Table 5.4: Projected Cocoa Yield with Climate Change

Year	*2020*				*2040*				*2060*		
CO_2 (ppm)	*400*	*400*	*400*	*CO_2 (ppm)*	*600*	*600*	*600*	*CO_2 (ppm)*	*800*	*800*	*800*
Temp. increase °C	*0.3*	*0.85*	*1.4*	*Temp. increase °C*	*0.4*	*1.4*	*2.4*	*Temp. increase °C*	*0.6*	*2*	*3.4*
Rainfall Change (%)				Rainfall Change (%)				Rainfall Change(%)			
14%	1.86	1.59	1.54	23%	1.55	1.33	1.02	32%	1.33	1.25	0.95
7%	2.10	1.85	1.79	11%	2.17	1.86	1.44	15%	1.59	1.50	1.14
0.40%	3.10	2.65	2.56	0.70%	3.10	2.65	2.05	1%	2.65	2.50	1.90
0	3.10	2.65	2.56	0	3.10	2.65	2.05	0	2.65	2.50	1.90
–0.40%	3.10	2.65	2.56	–0.70%	3.10	2.65	2.05	–1%	2.65	2.50	1.90
–7%	2.79	2.39	2.30	–11%	2.79	2.39	1.85	–15%	2.39	2.25	1.71
–14%	2.79	2.39	2.30	–23%	2.48	2.12	1.64	–32%	1.59	1.50	1.14

Note: Yield expressed in tonnes/ha/yr

Rice

Generally, long periods of sunshine are favourable for high rice yields. Growth is optimal when the daily air temperature is between 24°C and 36°C. The difference between day and night temperatures must be minimal during flowering and grain production. An irrigation water temperature of not less than 18°C is preferred.

Climate change can affect rice production in the following ways:

- Grain yields may decline by 9% to 10% for each 1°C rise in temperature.
- If drought conditions are prolonged, the current flooded rice ecosystem cannot be sustained. It may be necessary to develop non-flooded and dry land rice ecosystems to increase the level of national rice sufficiency.

National food security may thus be threatened in both cases. Table 5.5 shows that rice yield is sensitive to climate change.

Table 5.5: Projected Rice Yield with Climate Change

Year	*2020*			*2040*				*2060*			
CO_2 (ppm)	*400*	*400*	*400*	*CO_2 (ppm)*	*600*	*600*	*600*	*CO_2 (ppm)*	*800*	*800*	*800*
Temp. increase °C	*0.3*	*0.85*	*1.4*	*Temp. increase °C*	*0.4*	*1.4*	*2.4*	*Temp. increase °C*	*0.6*	*2*	*3.4*
Rainfall Change (%)				Rainfall Change (%)				Rainfall Change(%)			
14%	6.15	5.81	5.59	23%	7.34	6.94	6.54	32%	8.62	8.06	7.50
7%	6.65	6.31	6.09	11%	8.20	7.80	7.40	15%	9.83	9.27	8.71
0.40%	7.20	6.86	6.64	0.70%	9.04	8.64	8.24	1%	10.96	10.40	9.84
0%	7.20	6.86	6.64	0%	9.04	8.64	8.24	0%	10.96	10.40	9.84
–0.40%	7.20	6.86	6.64	–0.70%	9.04	8.64	8.24	–1%	10.96	10.40	9.84
–7%	6.70	6.38	6.18	–11%	8.05	7.69	7.34	–15%	9.32	8.84	8.37
–14%	6.19	5.90	5.71	–23%	6.96	6.65	6.35	–32%	7.45	7.07	6.69

Note: Yield expressed in tonnes / ha / yr

Agro-forestry

Climate change, which results in high rainfall, would be beneficial for the vegetative growth of agro-forestry species, as long as the rainfall is evenly distributed. Otherwise, an uneven rainfall distribution coupled with high temperatures, could lead to the occurrence of drought, whereby vegetative growth may be stunted. CO_2 elevation would result in a larger biomass production and carbon sequestration, provided that there are no other environmental constraints.

A selected number of agro-forestry species – such as *Khaya ivorensis* (African Mahogany), *Endosperma malaccense* (Sesenduk), *Tectona grandis* (Jati), *Acacia mangium* (Acasia) and *Azadirachta excelsa* (Sentang) – are being planted in this country. Climate change may have a minimal impact on this industry because of the large diversity of species, which are adaptable to a wider range of soil and climatic conditions.

Animal Husbandry

Livestock is usually raised under shade conditions in order to avoid direct heat load from solar radiation. Air temperature, relative humidity and airflow are the main environmental factors that affect production.

Since livestock are homeotherms, that is, they maintain a constant deep body temperature, heat produced must be lost to the atmosphere. A rise in air temperature would lead to heat stress being experienced by the animals. In fact, livestock – for example, cattle and broilers – would suffer heat stress, particularly during the hot periods of the day between 12 noon and 4 p.m., if air temperature rises. This can lead to reduced meat production.

Vegetable production, floriculture and aquaculture

Vegetable production and floriculture are relatively small-scale activities, involving intensive management. Problems posed by climate change can be tackled by new management strategies that involve further environmental inputs and adjustments. Sea level rise could inundate and destroy most coastal aquaculture activities.

Adaptation

Climate change results in stress on crop and animal production capacities. In order to sustain or increase production under varying climate conditions, various strategies such as the following could be considered:

- Develop plant varieties that are tolerant/resilient to high temperatures and high water use efficiency.
- Develop the means to maximise efficient usage of water and nutrient input.
- Preserve PFRs and water catchment areas to ensure adequate water supply for agriculture.
- Develop appropriate management practices for post-harvest handling to prevent spoilage of agricultural produce.
- Strengthen Integrated Pest Management and biocontrol procedures to deal with increased incidences of pests and diseases.
- Carry out research on the impact of environment on the physiology of animals so that the animals can be more comfortable and, in turn, perform optimally, for instance, develop more effective designs of animal housing structures to ameliorate heat stress.
- Establish semi-controlled/controlled plant and animal housing.
- Implement microclimatic modification through landscaping and agro-forestry.
- Develop appropriate responses to land use conversion that address socio-economic causes of land-use conversion.

Forestry

Assessment of Impacts

There are two important aspects to consider in assessing the impact of climate change on forests. First, forests form an essential component of the global carbon cycle, acting as a reservoir for storing carbon. Second, the forest ecosystem is an integral part of the global biological system, constantly reacting to variations in climate. Trees can adapt by modifying their own functions and physiological processes. The forest's response to climate change is biologically complex. The effects are not quickly observed. In fact, tropical forests are more vulnerable to land use change than to climatic changes, such that the amount of forest that is left will be the resulting balance between land conversion from economic activities and sustainable forest management practices that are imposed.

It is possible to consider the impacts of climate change on forests in Malaysia by examining its physiological processes, geographical distribution and biodiversity, as summarised in Table 5.6.

Table 5.6: Summary of Potential Physical Impacts of Climate Change on Forests

	Process/Habitat	*Impacts*
1.	Physiological process	Up to 40% increase in biomass growth due to increase in photosynthesis processes
2.	Forest distribution / habitat	
	(i) upland tropical rainforest	Expansion of suitable forest areas by 5–8%
	(ii) mangrove forest	Reduction in mangrove area by 15–20 % due to sea level rise
	(iii) forest plantation	Minimal impacts due to its limited area Increased susceptibility to pest and infestation of diseases. Increased fire occurrence
3.	Biodiversity	Still uncertain

Potential Impacts of Climate Change on the Physiology of the Forest

Several climatic variables – such as, air temperature, moisture availability and the concentration of ambient CO_2 – have direct effects on forest physiology, depending on the species, location, nutrient levels of the soil and other environmental conditions. Current scientific understanding indicates that elevated CO_2 concentrations may lead to increased biomass growth by as much as 40%, resulting from stimulated photosynthesis leading to increased concentrations of CO_2

inside the leaves. On the other hand, higher CO_2 levels may reduce the ratio of nitrogen to carbon in plant tissue that may affect the rate of litter breakdown. Trees in the forest also respond positively to temperature increase; the temperature and primary productivity are positively correlated but this is conditional upon the availability of water, which is in turn dependent on rainfall distribution.

Impacts on Forest Distribution

Given the temperature and CO_2 concentration projections of some GCMs, the expansion of upland forest by 5% to 8% may be expected. This would, however, be nullified by a loss of between 15% and 20% of mangrove forests located along the coastline as a result of sea level rise. The problem of climate change induced disease infestation on forest plantation species may also occur.

Forest Biodiversity

Tropical forests in Malaysia are rich in diversity and, therefore, the impacts of climate change on biodiversity is of great concern. The changing climate has likely effects on species composition of the forest, but marked variations are expected due to local effects of soil and topography. Given the intricate interrelationships between plant and animal species in tropical forests, the impact on any one species will have inevitable consequences for other species as well.

Adaptation Measures in Forestry

In the context of forestry, adaptation measures include forest management activities and policy tools that the country can adopt in order to reduce or ameliorate the potential impacts of climate change. In this regard, Malaysia is committed to adopting sustainable forest management (SFM). Possible measures relevant to climate change adaptation include the following:

(a) Forest plantation establishment
The establishment of forest plantations is essential to relieve

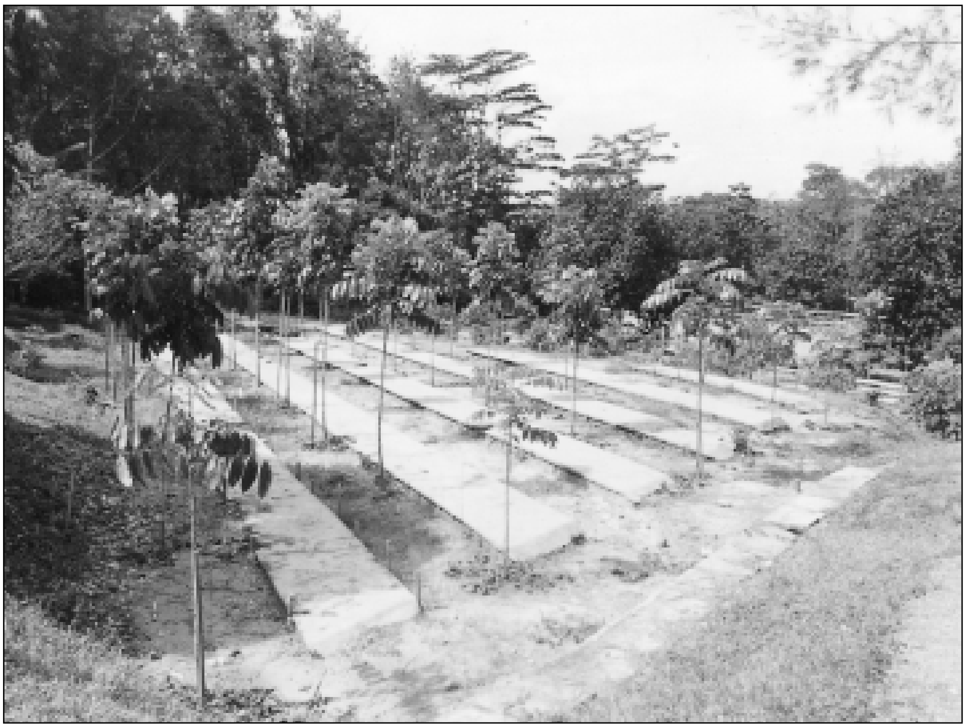
pressure on the natural forest besides optimising the use of marginal or unproductive lands. Shortages of wood can be avoided with forest plantations. In addition to using exotic species, suitable indigenous species should be encouraged. This includes planting of selected mangrove species in suitable areas along designated coastal belts. Nevertheless, intensive management of forest plantations is essential in view of increased susceptibility to pests and infestation of diseases resulting from climate change.

(b) A national seed bank collection
In response to the potential loss of forest species due to climate change, a concerted effort to collect and conserve selected varieties of forest species' seeds would be initiated nationwide through long-term seed storage techniques, such as cryo-preservation. Seed collections will cover a wide variety of genotypes for each species.

(c) Promotion of greater use of timber
The current level of usage of timber is relatively low compared to its availability. With new and improved technologies, long-life timber products, which are relatively maintenance free, are readily available. Greater use of timber and timber varieties, through sustainable forest management practices, will be promoted.

(d) Reduction of wastage in forest harvesting and increased efficiency in wood processing
The magnitude of wastage under current forestry practices is high. Hence, in response to a possible change in forest products output per unit area of forest, a reduction in wastage during harvesting is being instituted. Similarly, efficiency levels in wood processing industries would be increased by adopting new technologies and improving productivity.

(e) Strengthen and integrate conservation of protected areas
A network of protected areas within the PFRs will be expanded to ensure full representation of ecosystems and all ecological processes therein and to strengthen current in-situ conservation efforts. This network will comprise, among others, critical forest watersheds, mangrove areas, and hill forests.



A nursery planted with mahogany at Rantau Panjang Forest Plantation, Selangor

Water Resources

Simulation results of current GCMs reveal wide variations from model to model, especially on the amount and distribution of the rainfall to be expected. In addition, extreme events, which are of greater importance in determining the reliability of water resources systems, are not adequately simulated. In view of this, it is therefore more logical, at this stage, to adopt the sensitivity analysis approach in the assessment of climate change impacts on water resources. The quantitative impact assessments presented here are gross estimates due to the inherent uncertainty of GCMs and economic valuation of water resources related projects.

Flooding

Based on the analysis of storms of various intensities and durations, an increase of 10% to 20% in storm magnitude would result in a two-fold increase in design storm frequency or return period (the average expected time that lapses before the next storm occurrence of similar magnitude). Such an order of increase under the $2 \times CO_2$ climate change scenario is not unrealistic. These preliminary results provide at least a qualitative trend of the climate change induced impact on rainfall intensities.

As a result of the increase in the flood intensity and frequency, the costs of proposed flood mitigation plans to contain increased flood volumes would have to be revised upwards accordingly. The implications for existing flood mitigation schemes and drainage systems are, however, potentially far more serious. A doubling of the frequency of the design event, by definition, means a doubling of the frequency of the system ‘failure’. The social and economic costs of changing existing infrastructure to cope with more frequent and severe flooding are likely to be significant. Otherwise the alternative may be to accept a higher level of flooding risks and social inconvenience.

Based on the National Water Resources Study of 1982, the long-term annual average flood damage was estimated to be RM100 million. With a two-fold increase in storm frequency, an analysis of flood damage on selected river basins shows that the annual flood damage costs (at 1980 price level) could be increased by 2.13 times. This assessment is based on the flood damage cost at 1980 conditions. The effect of sea level rise resulting in floods, particularly along the low-lying coastal areas, was not taken into consideration in this exercise. Rapid urbanisation and the location of major towns throughout the country in coastal regions, which are low-lying and flat, make settlement patterns vulnerable to potential floods. Extensive investments have gone into building these towns and property values have surged to very high levels. Therefore, it can be reasonably expected that flood damage estimates, based on the 1980s figures will certainly be a gross under-estimate of the true magnitude, even after adjusting it to the current price level. A recent study projected the annual flood damage for the Klang River Basin alone to be at RM179.1 million in the year 2005.

Erosion and Sedimentation

Average annual soil erosion expressed in tonnes per km^2 per year for Peninsular Malaysia, Sabah and Sarawak are 355, 518 and 1,524, respectively. These differences in sediment load are primarily caused by the differences in land use practices. Studies on erosion and sedimentation rates indicate that a large proportion of the total annual load is produced during a few large storms. Consequently, there will be a higher risk of slope failures of riverbanks and hills, faster rate of sedimentation of reservoirs and channels, and more extensive loss of soil nutrients. For instance, in the Kelantan River, an increase of river discharge by 20% would cause a sediment load increase of 33%. In Sabah and Sarawak, an increase of 20% in high flow magnitudes and frequencies will translate to a 44% surge in sedimentation loads.

Water Availability

Climate change will have an impact on water availability (surface runoff). For a 1°C increase in temperature, in general, there is an increase in the potential evapotranspiration (PET) of between 3% and 9%, that is, about 90 mm additional loss of moisture on the average per annum. For a 3°C temperature increase, the PET is expected to rise to a range of 9% to 13%, which represents potentially about 170 mm of extra moisture loss.

With temperature increases of 1°C and 3°C, the reductions in long-term average monthly runoff during wet months are found to be relatively low, ranging between 1% and 5% and between 2% and 17%, respectively. During dry periods, the ranges for 1°C and 3°C scenarios are between 1% and 16% and between 1% and 24%, respectively.

In the case of a reduction in rainfall (10%) in combination with temperature rise (1°C and 3°C), the impact of rainfall reduction on runoff rates is found to be much more pronounced than that due to temperature rise. When rainfall totals are reduced by 10% across the whole time series, the corresponding decrease in runoff production reduces by an amount of between 12% and 31% during wet months. During dry months the reduction ranges from 13% to 38%. The combined effect of 10% reduction in rainfall with a 1°C rise in temperature results in a decrease in runoff of 13% to 35% and 14% to 43% during the wet and dry spells, respectively. On the other hand, for the case of combined effect with a 3°C rise in temperature, the reduction in runoff ranges from 13% to 48% and from 17% to 53% during the wet and dry months, respectively. Results of the runoff analysis for the five scenarios are summarised in Table 5.7.

Given the likely significant reductions in surface runoff as a result of climate change, the nation's water resources have to be carefully managed. In particular, storage capacities by dams and reservoirs must be developed to ensure the steady supply of water through a prolonged period of dryness. An estimated cost (in 1995) of providing each cubic metre of water at dam site is RM0.20. Thus, the annual cost of augmenting the 20% loss in domestic and industrial water supply of 3,806 million m^3 per annum would be RM152 million.

Water shortage would severely affect agricultural yield if the storage supply is insufficient to weather a prolonged drought. Wetland paddy, the principal source of the nation's food supply, is particularly sensitive to the problem. The off-season paddy crop is entirely dependent on irrigation. Other forms of cultivation as well as competing needs by industry and households will place further strain

Table 5.7: Impact of Rainfall and Temperature Changes on Runoff

Climate Change Parameter	*Magnitude of Change*	*Reduction in Runoff (%)*	
		Wet Months	*Dry Months*
Temperature	+1°C	1 to 5	1 to 16
Temperature	+3°C	2 to 17	1 to 24
Rainfall	–10%	12 to 31	13 to 38
Rainfall & Temp.	–10% & +1°C	13 to 35	14 to 43
Rainfall & Temp.	–10% & +3°C	13 to 48	17 to 53

Note: Percentage of reduction with respect to runoff under normal climatic conditions on the available water supply. During dry spells the low rate of runoff will also lead to deterioration in river water quality. Apart from presenting itself as a problem to the water authority, there is the more immediate threat to aquatic life as a result of water quality degradation in rivers.

Adaptive Measures and Policy Response

Information that is needed to forecast water availability includes improved estimation of regional population growth, land use changes, and likely shifts in water demand as a result of demographic and economic changes. In addition, improved information on the likely range of climatic conditions is an important prerequisite for a better formulation of adaptive and abatement measures. In general, options for reducing climatic and non-climatic stresses on water resources are similar. They include enlarging reservoir capacity, changing the operating rules of water resources systems, promoting widespread use of groundwater, and improving long- and short-range hydrologic forecasting. Changing land use practices to reduce sediment and nutrient loss to surface and groundwater could significantly enhance water quality.

One effective water conservation measure that may be considered is promotion of water resources development programmes that advocate the concept of demand management over supply management approach. These include, among others, the control of flood volume and pollution at source, use of low water-demanding technologies, recycling of water used, harnessing rain water for secondary consumption and a water pricing policy to discourage excessive use of resources (water and electricity). Other options include optimum land use planning and management to reduce water pollution and optimise demand pattern (spatially and temporally), and addressing erosion and sedimentation problems. For example, the introduction of adequate buffer zones in agriculture and forestry industries could significantly improve erosion and sedimentation conditions including the retardation of fertiliser transport to water bodies. Similar abatement measures being considered are reduced sediment production during property development and tighter enforcement of present water and land regulations.

In Malaysia, the implementation of EIA, Environment Management Plan (EMP), River Catchment Management Plan (RCMP) in major water resources and land development projects, the establishment of the National Water Resources Council in 1998, and the proposed establishment of river management authorities are progressive steps taken towards a better and more comprehensive watershed management future.

The National Water Resources Study in 1982 was the first attempt by the Government to come out with a comprehensive long-term plan for all aspects of water resources development. Since then, a number of the recommendations made have been taken up and followed through by the Government. Unlike its predecessor, the National Water Resources Study II (2000–50), which was started in 1997, concentrates on surface water resources and is expected to be completed by end-1999.

Education and awareness programmes to promote the idea of conservation and protection of the environment and water resources among the general public, especially the younger population, are other effective long-term strategies to mitigate the impacts of climate change on Malaysia's water resources.

Coastal Resources

Assessment of Biophysical Impacts

Three sea level rise scenarios of 20 cm, 50 cm, and 90 cm during the year of 2100 were examined. The biophysical impacts were assessed based largely on previous similar studies, but updated where relevant and aggregated to the national level. The likely biophysical impacts are classified into four broad categories: tidal inundation, shoreline erosion, increased wave action, and saline intrusion as summarised in Table 5.8.

(a) Tidal Inundation

Under the do-nothing scenario, the fringing mangrove belt is projected to be lost at the highest rate of sea level rise (0.9 cm / year) because the rise in the elevation of existing mudflats due to both

Table 5.8: Biophysical Impacts Resulting from Sea Level Rise

Type of Bio-physical Impact	*Sea Level Rise Scenario (Year 2100)*		
	20 cm (or 0.2 cm/yr)	*50 cm (or 0.5 cm/yr)*	*90 cm (or 0.9 cm/yr)*
Tidal Inundation (a) Mangrove-fringed mudflats (i) Bunded	Insignificant as bunds will be raised	Insignificant as bunds will be raised	Perhaps 300m strip may be lost (retreat bund)
(ii) Unbunded	Insignificant as bunds are likely to be built	Insignificant as bunds are likely to be built and topped up	Perhaps 300m strip may be lost (retreat bund)
(b) Sandy shores	Insignificant as existing ground level is higher	Insignificant as existing ground level is higher	Insignificant as existing ground level is higher
(c) Increased flooding	Reduced drainage efficiency of tidal control gates	Reduced drainage efficiency of tidal control gates	Tidal gates rendered non-operational and replaced by pumped drainage
Shoreline Erosion (a) Sandy shoreline retreat	Insignificant	Insignificant	Insignificant
(b) Mangrove loss	Vertical accretion rate able to keep pace	Vertical accretion rate able to keep pace	Total mangrove loss
Increased Wave Action	Insignificant	Reduced factor of safety, but taken into account during refurbishment if necessary	Taken into account during refurbishment
Saline Intrusion	Unlikely to be of concern due to a shift towards reservoir development		

organic and inorganic sediment deposition is unable to keep pace with the rising sea level. At the two lower rates of sea level rise (0.2 cm/year and 0.5 cm/year) and based on existing empirical evidence, however, the mangroves will likely remain, provided that the landward migration of the mangrove belt is not constrained by hinterland development. Attendant on the mangrove demise, a sizeable proportion of the coastal polder land of about 1,200 km^2 in Peninsular Malaysia alone will be submerged subsequent to bund failure, if the bunds are not shored up.

Mangrove eco-systems are vulnerable to sea level rise

(b) Shoreline Erosion

Shoreline erosion will account for another few hundred metres of shoreline retreat along the muddy margin. In the vicinity of river mouths and drainage outlets, the supply of fluvial sediments may help offset some of the coastal erosion somewhat. Along sandy coasts, sea level rise-induced shoreline retreat, as predicted by the Bruun Rule, may add another 30% to the rate of existing shoreline erosion.

The efficient drainage of hinterland depends upon the downstream control level imposed by the rising sea level. This will impede drainage and lead to increased flooding. The severity of impact is projected to range from a reduction in the efficiency of tidal gates to convey the requisite discharge to replacement by pumped drainage.

(c) Increased Wave Action

As a result of increased water depth in the surrounding seas, larger waves are projected to break along the coastline. This would occur with or even without a corresponding increase in storm activity as a larger water depth can support a larger unbroken wave height from a mechanistic standpoint. This is also the mechanism through which the projected enhanced coastal erosion will manifest. The consideration here is on the structural integrity of coastal facilities – such as, public infrastructure (for example, highways) and installations (for example, power plants). To the extent that such constructions have a designed service life due to material degradation through usage, usually of about 50 years, it is projected that any upgrading or outright replacement will be carried out through the normal annual operating budgets and development allocations under Malaysia's Five-Year Development Plans, since the projected rise in sea level will occur over time.

(d) Saline Intrusion

The least cause for concern seems to be the threat of saline intrusion. No doubt there will be tidal excursion farther up river. The potential threat of water contamination at water abstraction points is, however, considerably reduced due to a conscious shift in water sourcing development towards reservoirs, as well as the small volume of groundwater utilisation in comparison with that of surface water. The exception may be the case for the state of Kelantan and, to a lesser extent, the State of Terengganu, especially during a drought.

There are also other physical impacts that are considered important elsewhere but are not considered here due to lack of relevant data. Examples include submergence of corals, coral bleaching due to enhanced levels of CO_2 in the water, and loss of fisheries resources. It has been speculated that sea level rise and associated changes in ocean circulation patterns may change the migratory routes of fishes, thereby affecting fishing.

Other sea level rise-related impacts discussed in other sections include:

- the nation-wide loss of about 80,000 ha of land planted with rubber due to flooding as a result of the combination of increased rainfall and sea level rise of 1 m;

- abandonment of about 100,000 ha of land planted with oil palm in the event of a 1 m rise in sea level;
- a loss of between 15% and 20% of mangrove forests located along the coastline;
- possible relocation of shore-based power stations; and
- additional cathodic protection of offshore facilities due to vertical ascent of the splash zone.

All these impacts, with the possible exception of those affecting offshore facilities, are subsumed, one way or another under the items considered in Table 5.8. They are considered as further elaboration on specific impacts and do not materially alter the overall scenario depicted in the same Table.

Assessment of Socio-economic Impacts

Based on empirical work done on the project scale, an attempt has been made to quantify the economic implications arising from the projected biophysical impacts as summarised in Table 5.9. The difficulty is in extending these project-scale estimates to the national aggregate. In this case, a simple linear extrapolation based on shoreline length and area extent has been used for aggregation purposes, wherever possible. The main economic loss is projected to be the cessation of economic activities, principally agriculture production, along vulnerable stretches of coastline as a result of direct inundation in the event of bund breach. The potential loss in terms of fisheries resources is related to a 20% loss of mangrove areas, which serve as habitat for fish juveniles. Hence, the impact on fisheries reported in Table 5.9 refers to that resulting from the loss of habitat, and not as a direct result of sea level rise.

The projected economic loss associated with increased flooding, which comprises primarily damage to, and replacement/upgrading of, infrastructure, disruption of economic activity, and relocation of flood victims, is to be viewed as the worst-case scenario. This qualification is

Table 5.9: Socio-economic Impacts resulting from Sea Level Rise

Type of Impact	Socio-economic Impacts based on the High Rate of Sea Level Rise (0.9cm / yr)
Loss of agricultural production from eroded / inundated lands	RM46 million for Western Johor Agricultural Development Project area. The West Johor Project area accounts for about 25% of the national drainage areas.
Displacement and relocation of flood victims with associated disruption of business / economic activities resulting from increased flooding	Long-term annual flood damage estimated at about RM88 million for Peninsular Malaysia and RM12 million for Sabah / Sarawak based on 1980 price level. If the flood frequency is doubled, the annual flood damage will increase by 1.67 times.
Loss of fisheries production due to mangrove loss	RM300 million loss based on 20% loss of mangrove resulting in a loss of about 70,000 tonnes of prawn production valued at RM4,500 / tonne.
Interruption of port operation	May see some improvement due to reduced siltation.

relevant since the loss estimation quoted here includes all coastal and inland floods. Inland floods are not affected by impeded drainage caused by a heightened sea level, but are, however, the result of inadequate conveyance capacity of rivers and drainage channels. Also, it needs to be borne in mind that the section on Water Resources in this report has identified increased surface runoff as a likely consequence of increased precipitation, a phenomenon linked with climate change. Therefore, a portion of the future discharges is likely to be related to climate change, which would further stress the flow capacity of inland drainage networks. Hence, on balance and due to a shortage of data to indicate otherwise, the projected loss in this regard seems reasonable.

While some of the estimates made here are based on quantitative procedure, it must be recognised that they remain as preliminary estimates, and further work is required for refinement and a better quantification of the associated uncertainty.

Adaptation Measures

Several adaptation measures for mitigating these impacts are considered. They comprise specific shore stabilisation methods using structural means, management approach through regulation of coastal land use, and the broader context of holistic policy framework, such as integrated coastal zone management.

(a) Defend
The defend option, which includes building bunds/seawalls/levees/dykes, raising levee height where required, dumping sand, especially on recreational beaches, and dumping mud on a retreating shoreline, tends to combat, instead of work with, natural processes and will incur a high implementation and maintenance cost. Under normal circumstances, this option is viable only if the land and infrastructure being protected are of high economic value or of strategic importance. When deciding to defend, the preferred approach is beach/mud nourishment locally, and sediment management regionally.

(b) Accommodate
This measure accepts a greater degree of flooding by regulating building development in the coastal zone, or by designing buildings that are suitable in a rising sea environment or that which can be easily relocated. Alternatively, a new form of land utilisation is adopted to sustain economic activities, such as converting drowning agricultural lands to pond or cage aquaculture. Education is important here to help those affected change their economic activities.

(c) Retreat
This allows the sea and wetlands to encroach onto land, often necessitating the relocation of the people affected. Presently, this measure tends to be reactive in response to bund breaching and suffers from an inability to defend the protected area. Ideally, this

measure should be proactive so that the programme of managed retreat can be planned and implemented in order to minimise adverse impacts or to take advantage of the new environment created. This option, although chosen in areas of marginal agricultural production, is unpopular, results in losses of property and crops, and often involves relocating the people affected. Another proactive retreat measure entails the regulation of development in the coastal zone by imposing adequate construction setbacks, usually 60 m from the high water mark, or by creating a coastal buffer zone.

(d) Counter Attack

Instead of defending the coastline along its present position, it sometimes makes economic sense to transfer the line of defence seaward and reclaim the intervening area. This measure has the added advantage of being able to incorporate the projected sea level rise into its planning and design. This measure has become popular in large segments of the west coast of Peninsular Malaysia which are either already reclaimed or are in the process of being reclaimed.

(e) Coastal Land Buyback

This is a proactive approach to regulate land use through converting private ownership to public domain whereby the land is left as a nature reserve/corridor within which the natural variation of shoreline movement is permitted to take place. This has, however, to be preceded by a national mapping exercise to identify areas vulnerable to sea level rise.

(f) Integrated Coastal Zone Management (ICZM)

To sustain economic use and development of the coastal zone, Malaysia is now in the process of embarking on an ICZM initiative in which the potential impacts of sea level rise are given special consideration in planning. This policy framework serves as an umbrella concept within which the adaptation measures (a) to (e) can be viewed as components. The element of climate change is just one of many factors that will be considered in formulating the ICZM, which has the over-arching aim of promoting wise use of coastal resources compatible with environmental imperatives.

These adaptation measures are feasible in the Malaysian context, but additional efforts are needed to quantify them in terms of cost implications. Some of these additional efforts include further research and development in improving the science of prediction of the responses and quantitative bases for estimating impacts and economic costs.

Public Health

Region-specific scenarios are not available currently and WHO has stated that, due to this factor, predictions on health effects caused by climate change have to remain general and speculative. Nevertheless, climate change is expected to cause adverse health consequences by the middle of the next century. A direct impact could be deaths due to heat stress or respiratory diseases due to air pollution, while indirect effects could include increased food and water borne diseases resulting from changes in rainfall pattern. There could also be an increase in vector-borne diseases – such as, malaria and dengue fever – as changes in temperature will increase the availability of suitable breeding habitats for the vectors.

The occurrence of vector-borne diseases is widespread, ranging from the tropics and subtropics to the temperate climate zones. Increased incidences of dengue and dengue haemorraghic fever are observed especially in urban areas after heavy rainfall. The rainfall provides suitable breeding conditions for *Aedes albopictus* and *Aedes aegypti* mosquitoes. An Institute for Medical Research (IMR) model shows that high rainfall is required for high transmission of dengue. Vectors require specific ecosystems for survival and reproduction. Therefore, climate change would have a direct effect on vector distribution and consequently in diseases, such as, dengue, malaria, filariasis and Japanese encephalitis.

Malaria remains the most common vector-borne disease. Although the number of malaria cases detected in the country has dropped from 243,870 in 1961 to 26,652 in 1997, climate change can trigger a resurgence of the disease. The vectors exhibit definite seasonal prevalence. Increases in temperature and rainfall would most probably

A boardwalk in the Matang forest to prevent damage to the delicate eco-system and for easy access during high tide

allow malaria vectors to survive in areas immediately surrounding their current distribution limits. How far these areas are extended would depend on the magnitude of the change in climate. In areas where malaria is seasonal, a dramatic increase in disease prevalence occurs in all age groups during the annual transmission season because previously acquired immunity in the host is lost in the non-transmission season. Potential lengthening or shortening of the vector-breeding season may lead to shifts in malaria incidence and prevalence. Similarly, in areas where there is perennial transmission, an increase in malaria incidence may occur, due to improved vector-breeding conditions. There is a possibility that an increase in sea level may lead to a corresponding rise in coastal vectors due to an increase in breeding ground, as there will be more areas covered with brackish water. Deforestation, without proper and sound land use practice, may lead to a higher incidence of malaria as more areas are made available for vector breeding.

The vectors of arboviral diseases are known to breed over a wide range of climatic zones and may invade areas that are not infested at present, if temperature and humidity rise. Because arboviral diseases can, under favourable environmental conditions, change from endemic to epidemic forms, caution must be exercised in predicting what might happen to these diseases as a result of climate change. An increase in temperature shortens the reproductive cycle and extrinsic development period of the pathogens, allowing transmission of diseases, such as Japanese encephalitis (JE). JE has been known to occur in Malaysia since 1951 and the virus was first isolated in 1952. The *Culex* mosquito transmits it. Small-scale serological surveys have shown that JE is a common infection in humans, horses and other animals, such as pigs. The recent viral encephalitis (combination of JE virus and the newly-identified Nipah virus) outbreak in Malaysia (1998–99) has recorded more than 100 human fatalities and resulted in the culling of thousands of pigs. Epidemiological and animal research is on-going to establish whether there is a relationship between various environmental parameters.

As in the case of vector-borne diseases, water-borne diseases are also concentrated in the tropical and subtropical regions of the world. Food and water-borne diseases are due to indirect health effects of a changing climate. These include: (1) diarrhoeal diseases caused by a variety of organisms (such as, *Escherichia coli., Vibrio cholera, salmonellae* and *viruses*), (2) other viral diseases (such as, hepatitis A and poliomyelitis), and (3) protozoan diseases (such as, giardiasis and amoebic dysentery). Contaminated hands, food, and objects can also transmit these diseases. There were major cholera outbreaks in the country in 1974, 1983, 1990, and 1995. The 1995 outbreak was the largest and the state of Sabah reported 2,046 cases and 26 deaths. Some studies have shown that the agents which transmit cholera naturally live in very small marine organisms (identified as plankton) in both ocean and river water. Changes in monsoon patterns can trigger a bloom of these organisms resulting in a cholera outbreak. While little can be said about the direct effects of climate change on this pathogen, it is obvious that they will be largely overshadowed by the indirect effects of migration and resettlement and the lack of access to safe drinking water.

Climate and seasonality are important determinants in the incidence of air-borne diseases, such as, asthma, and other respiratory infections. The net effects of global climate change on such diseases are, however, difficult to forecast. There are recent reports of links between El Nino and a range of health conditions. In Southeast Asia, the El Nino effect was strongly felt in 1997. The prolonged drought contributed to the development of forest fires and this, coupled with the existing wind pattern, caused widespread smoke/haze over the Southeast Asian region. Ministry of Health records show there was an increase of complaints related to conjunctivitis, bronchitis and asthma among the local population during the haze episodes of 1990, 1991,1994 and 1997 in Malaysia.

El Nino is brought about by temperature changes in the Pacific currents resulting in varying weather conditions around the world. The increase in temperature was felt in the Southeast Asian region. These changing hygrothermal conditions can be expected to influence human health and well-being in proportion to the degree of heat stress. Heat stress can cause mild cardiovascular problems to severe tissue damage and, in extreme cases, even death. These effects are concentrated among vulnerable groups of people, such as, the elderly, the very young, the malnourished and those with pre-existing respiratory and cardiovascular conditions.

The Ministry of Health has an emergency preparedness and disaster management plan for the whole country. This plan is periodically updated to address emerging problems in health including those due to environmental factors and climate change. Strengthening of the existing programme for international health surveillance and monitoring systems is an ongoing process. There are also plans for effective long-term economic, development and health strategies to prevent or mitigate climate change induced health effects. Multidisciplinary approach and collaboration with other agencies – such as, agricultural, meteorological, environmental and planning agencies – will be intensified to ensure that adequate weightage is given to health impacts due to climate change in Malaysia.

Table 5.10 summarises the possible effects of climate change on public health.

Energy Sector

This section looks at the impact of the resulting climate change on the energy sector, specifically on electricity production and consumption, and the oil and gas industries, in relation to the projected sea level rise, changes in the ambient air temperature, water temperature, and rainfall. The transport sector is also briefly mentioned here.

Impact of Climate Change on Electricity Production

Effect of sea level rise

Sea level rise is a major concern to electrical power producers because most of their thermal power plants are located near the sea to water-cool the plants. Coastal erosion is a major problem affecting power plants located along the coast. For example, the Paka Power Station in Terengganu is experiencing the effects of severe coastal erosion and has to be defended by costly structural works (such as, concrete sea walls and huge boulder ramparts). Under present circumstances, severe erosion may eventually result in the relocation of the plant. This process may be accelerated if there is a sea level rise.

Table 5.10 Summary of Possible Effects of Climate Change on Public Health

Climate change scenario	Temperature change +0.6 to 3.4°C in 60 years. Rainfall –1 to +32% in 60 years. Sea level 13–94 cm in 100 years.
Health concerns	Region-specific scenarios are not available. Predictions have to be general and speculative.
Vector-borne diseases – tropics, sub-tropics to temperate zones	*Dengue* – Increase in urban areas. High rainfall required for high transmission. *Malaria* **-** Specific temperature & rainfall required for vector breeding. Increase in sea level & deforestation without proper and sound land use may lead to increased vector breeding ground. **Transmission areas** *Seasonal areas* – Increase in disease due to loss of immunity. *Perennial areas* – Increase due to improved vector breeding conditions. **Viral diseases** – Increase with increases in humidity & temperature. Can change from endemic to epidemic forms. E.g. Japanese encephalitis.
Water-borne diseases – tropics and sub-tropics	Little can be said about the direct effect of climate change on these pathogens. **Bacterial** – *Escherichia coli, Vibrio cholera, Salmonella* sp. **Viral** – Hepatitis A, Poliomyelitis. **Protozoa** – *Giardia* sp. Amoeba sp.
Airborne diseases	Increase in particulate (PM10) concentrations, high temperatures and humidity cause/ aggravate conjunctivitis, bronchitis & asthma.

Building setbacks would provide the buffer for protection against sea level rise and beach erosion. With the rise in sea level, the splash zone for offshore facilities of all the power plants requires extra painting and cathodic protection. The potential increase in the occurrence of severe tropical storms will escalate operational and maintenance costs of electricity producers.

Effect of sea water temperature

Most of the thermal power plants in Malaysia are water-cooled. For steam power plants, water temperature is important for its condenser and any increase will directly affect its operational efficiency. A rise in the water temperature will decrease turbine heat rate and reduce plant efficiency and power output. Higher temperatures in the cooling water also affect the condenser vacuum. These effects will lead to higher production costs. An increase of 1°C in the temperature of sea water will result in an 8% efficiency drop in the performance of a typical 110 MW steam turbine. Thus, the total impact on steam turbines of combined capacity of about 4,000 MW would be high.

Effect of ambient air temperature

Generally, the present gas turbine installations are designed to operate with an average ambient air temperature of 30°C. Therefore, any increase in the ambient air temperature will reduce the power output of the gas turbine. The effect of ambient temperature on the output of a typical 135 MW gas turbine shows a loss of 2% power output resulting from a rise of 1°C in ambient air temperature. This would translate to a loss of 132 MW from a total of 6,600 MW of installed capacity running on gas turbines for a 1°C rise in ambient air temperature.

Effect of rainfall

In 1998, 14% (nearly 2,000 MW) of electricity generation is from hydroelectric schemes. Changes in the rainfall pattern and occurrence of drought can have an adverse effect on water supplies, thereby limiting the capacity of hydroelectric generation since domestic water consumption has higher priority than power generation.

A decrease in rainfall in the hydroelectric scheme catchment areas would drastically reduce the generating capability of the hydroelectric schemes. The resulting interruptions in power supply due to limitations in available power would have serious repercussions on all sectors.

Siltation is another problem faced by power stations near the sea, affecting the plant's cooling system and coal handling facilities. An increase in rainfall would result in increased run-off which would increase sediment load and further aggravate siltation. The Kapar Power Station in Selangor is one example of a station experiencing this problem. Dredging is being carried out to restore the navigability of the coal handling facility and to increase the suction head for the cooling water.

Impact of Climate Change on Electricity Consumption

Effect of ambient air temperature rise

The projected increase of 2°C to 4°C in the mean air temperature will be a major factor in the increased use of electricity. The increase in ambient temperature will prompt the public to use more electrical energy to cool themselves by increasing the use of fans and air conditioning, although the extent by which energy usage will increase has not yet been determined.

A summary of the potential impacts and costs to the electricity sector as a result of climate change is shown in Table 5.11.

Impact of Climate Change on the Oil and Gas Industry

Sea Level Rise

Upstream operation for exploration and production

Sea level rise will ultimately increase the cost of operations as offshore boat landing facilities (platforms) will be submerged and new landing facilities need to be built or other alternative forms of transport used. Furthermore, splash zones on offshore platforms are required to be

Table 5.11: Projected Impacts, Adaptation/Mitigation Measures and Costs in the Electricity Sector

Climate change	*Impact*	*Unit cost of impact*	*Estimated cost of impact*	*Adaptation/ mitigation*
For every 1°C rise in ambient air temperature	[1]Loss in gas turbine power output by 2%	[2]Loss of RM0.67 million / yr per 110MW gas turbine	About RM40 million / yr for 6,600 MW capacity	Air intake cooling
	Loss of 2% power out-put of hydro turbine	Loss of RM0.9 million / yr per 100 MW hydro turbine	About RM18 million / yr for 2,000 MW capacity	Precipitation enhancement
For every 1°C rise in water temperature	[3]Loss of 8% power output of steam turbine	[4]Loss of RM2.6 million / yr per 110 MW steam turbine	About RM95 million / yr for 4,000 MW capacity	Air cool condenser
1 m rise in sea level	Erosion of beaches fronting power station	Specific to a few stations. Currently RM2 million is spent annually to mitigate erosion problems at each of the stations affected by coastal erosion.		Wave break waters
				Relocation of power plants
	Corrosion	RM3 million / yr per station	RM18 million / yr for six stations	Cathodic protection, painting

Note: [1] Design ambient air temperature: 30°C, an increase of 1°C average for 12 hours / day
[2] Load factor of 70%
[3] Design ambient sea water temperature: 32°C, an increase of 1°C average for 12 hours / day
[4] Load factor of 70%

raised, refurbished and repainted. This work is costly and dangerous, given the nature of turbulence in the sea and underwater currents.

Coastal onshore terminals, ports and refineries

Sea level rise will inundate low-lying areas along the coast and heighten coastal erosion. Flooding interferes with coastal onshore activities resulting in delays and loss of revenue. Protective measures (such as building retaining walls to reduce coastal erosion and prevent floods) would be costly.

Increase in Tropical Storms

Offshore terminals

More frequent tropical storms would interfere with platform operations resulting in higher operational and maintenance costs.

Ports

Increase in mean water level in shipping channels and ports would have a positive effect on the manoeuvrability of ships, which have a small keel clearance. On the other hand, increased tropical storms would affect shipping and port operations, and may result in an increase in late cargo deliveries and higher operational costs.

Increase in Ambient Air and Water Temperature

Liquefied gas plant operation

A rise in water temperature will also affect water-cooling systems; a higher set point for temperature regulation will have to be set when the incoming water temperature becomes higher. Higher ambient air temperature will, in turn, raise the temperature of the piping, heat exchangers and process equipment such that the returning water temperature will be higher. This will add costs to efforts to reduce the water temperature. Operating at a higher ambient temperature would also reduce plant efficiency and productivity if the process is temperature sensitive.

Higher water temperatures will also increase evaporation rates, leading to more water loss and, therefore, higher make up water requirements.

Increase/Decrease in Rainfall

All onshore facilities

Either increased or decreased rainfall will affect make up water quality of all plants requiring water for cooling or processing. Higher rainfall may cause floods that may affect coastal facilities. Wastewater treatment plants may overflow and contamination may occur. Additional costs for mitigation measures (such as, pumping, drainage systems and maintenance) will be required. Flood control programmes (such as, gravity drainage systems or impoundment) will have to be implemented to protect onshore facilities, thereby increasing operational costs. The projected impacts and adaptation/mitigation measures in the oil and gas sector are summarised in Table 5.12.

Impact of Climate Change on Transport Sector

In 1997, there were more than 8.5 million vehicles registered in Malaysia. At the current rate of newly registered vehicles, the scale of impact could be quite substantial. The main effect of climate change on the transport sector will be the change in ambient air temperature. It is expected that more fuel will be consumed per kilometre run due to a drop in engine performance with increased ambient temperature. The efficiency of the air conditioning system will be similarly affected. In addition, more energy will be required to cool the vehicle to the same level as before. Until now, however, no study has been done specifically to assess fuel consumption during hot days in relation to efficiency of motor engines and air conditioning systems.

Fuel loss due to evaporation during transportation, transfers between tanker and station and filling-up is a common phenomenon. With increased air temperature and higher evaporation rate, fuel loss can be high.

Table 5.12: Projected Impacts and Adaptation/Mitigation Measures in Oil and Gas Sector

Climate Change	*Impact*	*Adaptation/Mitigation*
Rise in sea level	Offshore boat landing facilities will be submerged Coastal facilities will be flooded Loading and unloading activities at the port will be interrupted The port cannot function for its intended purpose	Raise the offshore platform which is costly Build retaining wall / dredging Build retaining wall / dredging Build retaining wall / dredging
Higher rainfall (flooding)	Operation of coastal facilities will be affected Overflow of waste water treatment plant Soil and ground water pollution	Install water pump; Upgrade irrigation system Install water pump; Upgrade irrigation system Clean the polluted area
Increase in tropical storms	Crew changeovers at the offshore terminals will be delayed An increase in late cargo deliveries	Reschedule Reschedule
Increase in air & water temperature	Reduced efficiency of cooling water systems Higher make-up water requirement More fuel consumption in transport	Upgrade existing cooling system Use some external cooling system Use more efficient air conditioning systems

6. Research and Systematic Observation

Research

Based on climate records, a few analyses to detect climate change have been carried out by the Malaysian Meteorological Service (MMS). The general findings were that temperature records indicated warming trends, while rainfall data did not show any consistent and significant variations.

Malaysian scientists are actively involved in the IGBP/START/SARCS regional programmes on global change. A study to develop an operational methodology for monitoring land use and land cover changes was conducted by UKM. This study also made an analysis of the causal factors or driving forces of those land use and land cover changes. Also, environmental issues resulting from land use and land cover changes were analysed and the parameters vital to the management of watersheds were identified. The second phase of this project is currently being carried out.

The Malaysian Centre for Remote Sensing (MACRES) was established in August 1988 and became fully operational in January 1990. The centre is equipped with satellite data image processing and geographic information system facilities. A satellite ground receiving station is being constructed and scheduled for completion in 1999. MACRES acts as a principal research and development organisation in areas of remote sensing and related technologies in the country and co-ordinates the implementation of remote sensing activities in the country.

A major outcome of this project is the establishment of the earth resource observation laboratory at UKM. Scientists who were trained under the START's capacity-building workshops manage the laboratory. The National IGBP/START Committee is also planning a training workshop for local scientists at this laboratory.

A SARCS/WOTRO/LOICZ co-ordinated project entitled "Carbon and Nutrient Fluxes and Social-economic Studies of the Merbok Mangrove Ecosystem" is ongoing at the Centre for Coastal and Marine Studies, Universiti Sains Malaysia (USM). It is expected to be completed in 1999. This project brought together the physical and social scientists to understand the interaction between the socio-economic and natural science aspects of global change.

Malaysia does not have its own GCM. Climate change scenarios used in national studies are derived from GCMs of other meteorological centres. The climate features simulated by GCMs agree well at global scale. At the regional and local scales, however, the outputs from various GCMs differ significantly. The large range of values of meteorological variables at any one locality produced by different GCMs make it unwise to use just one GCM to generate climate change scenarios for Malaysia. Therefore, Malaysia adopted the approach of using a range of scenarios to assess the impact of climate change on key economic activities. This is similar to performing a sensitivity study.

It is useful to develop a regional climate model nested within a bigger global model. The regional model, which has a finer resolution, is able to incorporate smaller local weather features. Presently, MMS is developing a regional climate model for Southeast Asia. The model, once completed and validated, is expected to assist future development of national climate change scenarios.

Long-term systematic observations at national and regional levels are crucial for the monitoring of climate and its changes. The decision in COP4 related to the strengthening of observational network and support for the Global Climate Observation System (GCOS) reiterated the need for long-term systematic observations.

The continuous monitoring of climate change and its impacts form the basis for scientific research for better understanding of the climate system. To this end, the collection of data, apart from climatological data, shall include socio-economic, agriculture, forestry and hydrological data. They essentially form the national database for climate. Nevertheless, such a national systematic database related to climate change requires co-operation and participation of all related scientists. A national mechanism needs to be developed in order to co-ordinate scientific research on climate change with an aim to reduce the uncertainties and to provide options for policymakers.

Data Collection and Monitoring

One of the main responsibilities of MMS is to monitor the weather and archive the data. A network of stations across the country monitor various meteorological variables at the surface and in the atmosphere. There are about 400 auxiliary meteorological stations, 34 principal meteorological stations and eight upper air stations. The auxiliary stations measure daily values of temperature, humidity and rainfall, while the principal stations measure a more complete set of hourly values of temperature, humidity, rainfall, evaporation, sunshine hours, solar radiation and wind speed and direction. The upper air stations measure the temperature, humidity, pressure and wind speed and

MMS

A balloon with an attached radiosonde is being released at an upper air station to measure the various meteorological parameters of the atmosphere.

direction at various heights of the atmosphere. Table 6.1 shows the length of records of MMS stations.

MMS is the National Climate Data Centre that maintains a climatological databank. Climate data are subjected to stringent checking procedures before being stored. The data, after being checked,

Table 6.1: Length of Records of MMS Stations

No. of Stations	*Length of Records*
14%	> 50 years
5%	40–50 years
75%	10–40 years
6%	< 10 years

Source: MMS

MMS

Trained observers calibrate a rainfall recorder to ensure accurate observations

are compiled and published in bulletins for distribution to users. MMS also uses the World Meteorological Organisation (WMO)'s CLICOM software to manage climate data. This software operates on personal computers. From past weather data, MMS has developed a climate database. Researchers and policymakers have ready access to the data set. Scientists who conduct climate studies, including studies on climate change and its impacts, use this database. Monthly and annual summaries of the data are published and distributed.

Besides MMS, the Department of Irrigation and Drainage (DID) also has a network of 1,358 rainfall stations. The Department also monitors river stage and discharge at 216 stations, suspended sediment at 108 stations, and water quality at 70 stations. The Department uses the data to aid basic water resources assessment and in flood forecasting and warning at major rivers. Table 6.2 shows the length of records of DID stations.

The ozone content of the atmosphere (troposphere and stratosphere) is also measured at the headquarters of the MMS. Malaysia also has one Background Air Pollution Monitoring Station under the Global Atmospheric Watch Programme of WMO. This station was established according to the guidelines of WMO to measure air pollution at the regional level at places away from urban centres and large pollution sources. It is equipped to measure aerosol optical depth and suspended particulate matter concentrations. Besides this station, air pollution is also monitored at all the principal meteorological stations which measure chemical composition of rainfall, dry fallout, suspended particulate concentration, turbidity of atmosphere and acidity of rain.

Table 6.2: Length of Records of DID Rainfall Stations

No. of Stations	*Length of Records*
16%	> 60 years
18%	50–60 years
62%	20–50 years
4%	< 20 years

Source: DID

In order to cover more extensive areas of the country, the Government also contracted a private company to monitor air pollution. The company regularly provides information on air pollution conditions to the Government.

The Malaysian Department of Survey and Mapping has been establishing a network of tidal observation stations to obtain tidal data for the determination of mean sea level as reference for the National Geodetic Vertical Datum. Presently, there are 11 stations in Peninsular Malaysia, three in Sarawak, five in Sabah and one in Labuan.

The present network of meteorological, environmental and sea-level monitoring stations is not dense enough to adequately cover all the various zones of the country. With respect to climate monitoring, this is particularly true for the interior highland regions. In terms of length of record, only a few stations have data exceeding 50 years. Therefore, the data sets are not adequate for global change studies. There is a need to improve its network of monitoring stations.

Monitoring of Energy Production and Consumption

The Ministry of Energy, Communications and Multimedia (MECM) has been publishing data on the national energy balance. The Malaysia Energy Centre (MEC) was established in 1998 and administered by MECM. The organisation is responsible for publishing data on the national energy balance as part of its functions.

A Malaysia Energy Database and Information System (MEDIS) is being developed to support integrated national energy planning. Ensuing from this, energy modelling and forecasting to produce a long-term energy outlook would be required. Such a projection exercise not only looks at energy demands by economic activities but must also consider the prospects of meeting demands through various energy options.

7. Education, Training and Public Participation

General Public Awareness

Concerns over environmental issues among the general public in Malaysia vary widely. Attitudes are also largely influenced by mass media coverage of environmental matters. The extent of coverage by the mass media, in turn, depends on environment-related events. For example, there was greater environmental awareness during the past couple of years because of the haze problem. The severe region-wide haze in 1997, which was associated with the El-Nino phenomenon and forest fires, was given prominent coverage by both the local and foreign media. There was also much media coverage of the reverse effects of the La Nina phenomenon in 1998, which was projected to cause landslides and floods.

Despite the heightened public awareness of environmental issues generally, many people lack understanding of the delicate inter-relationships between man, and all species of animals and plants. Thus, few are able to relate their everyday activities (such as the emission of GHGs) to environmental consequences, both in the short- and long-term. While some forms of pollution, such as discharging sludge into rivers, can be readily observed, other kinds of environmental problems may take a much longer time to manifest themselves.

Fewer still have knowledge about the various institutional initiatives being taken at the national, regional, international, multilateral or global level to improve the environment. A random survey among the public in early 1998 revealed that many Malaysians were not fully aware of the existence or functions of the UNFCCC, although efforts were made by the Government, especially MOSTE and MMS, and some NGOs to publicise institutional initiatives at seminars and talks. Also, in the electronic media, issues on climate change do not generally receive much attention and coverage apart from the occasional documentaries, such as the one on climate change aired over a local TV station in 1997.

Increasing public awareness of renewable energy and its uses is also an area of concern under the World Solar Programme of the MECM.

Relevant NGOs in Malaysia have organised themselves under the Malaysian Climate Change Group (MCCG) to generate discussion and dialogue with stakeholders. In collaboration with the MMS, the MCCG is preparing an educational fact-sheet for general distribution. The MCCG has also been closely following the UNFCCC intergovernmental negotiating process, besides monitoring the alternative sources of information on climate change being circulated among the NGOs worldwide.

Education

The Government has adopted a long-term strategy to carry out environmental education through a multi-disciplinary and holistic approach. School curricula covering the environment are being formulated at pre-school right through to institutions of higher learning in Malaysia. Meanwhile, representatives of the private sector,

Nature walk – environment appreciation for the young.

NGOs and the mass media are complementing the Government's efforts in promoting environmental education.

The Department of Environment (DOE) has, for many years, been operating an Environmental Education Unit. This Unit plays a catalytic role to organise and promote environmental awareness programmes and activities in order to increase environmental awareness among the public. The Department organises annually the National Environment Week, which aims to foster public participation in environmental activities. The Environment Quality Report is published on an annual basis to enhance the public's awareness of the state of the country's environment.

Local universities offer various environmental and climate-related courses at the undergraduate and graduate levels. The DID also runs the UNESCO International Hydrological Programme, designed to educate the public about the nation's water resources and hydrological system. The Business Council for Sustainable Development has been educating companies and corporations on relevant environmental issues through seminars, dialogues and workshops. FMM and MCCI have also organised similar events.

Public Participation and the Role of NGOs

NGOs in Malaysia with an interest in environmental issues have played a key and active role, both within and outside the country, to advocate better monitoring, surveillance and management of the environment. The NGOs are also an important source of activity and information, which have often contributed towards increasing the level of environmental awareness among the general public.

In keeping with the strategy of the Government to promote and pursue sustainable development, as guided by specific policies and programmes based on national priorities and aspirations, NGOs in Malaysia are also advocating the adoption and implementation of various plans and projects on sustainable development at the local, national, regional, and international levels.

Malaysia's desire to achieve the status of a developed country by the year 2020 will require rapid economic growth and expansion, especially in the urban, industrial and commercial sectors. Economic growth is guided by the principles of sustainable development. The extent to which sustainable development is achieved will ultimately depend on the ability of the country to monitor and manage the impacts of economic activities on the environment. NGOs continue to advocate national efforts to address such issues as the economics of climate change, the compilation and publication of timely data on GHG emissions, and projections of energy consumption by different end-users.

The MCCG has been closely working with the Climate Action Network at the international level and sharing information with other NGOs in the region. CETDEM has recently started a series of public awareness campaigns on energy efficiency and renewable energy with the support of the MECM as well as the Ministry of Education. The prizes for a secondary school level poster competition, which formed the first stage of these campaigns, were presented by the Prime Minister on 8th June at the launching of the World Renewable Energy Congress '99 in the capital of Kuala Lumpur. The Congress itself marked a major effort by the Government, private sector and researchers, to address renewable energy on a broad scale.

8. Identifying Strategies to address Climate Change Issues

The database, emission factors and models are the means to monitor GHG emissions. The assigned government agency where these are kept and maintained becomes the focal point for a variety of enabling activities: scientists working to reduce uncertainties, decision makers conducting policy simulations according to alternative prescriptions, engineers making efforts to widen the technological options and the media attempting to disseminate useful information for greater public awareness and understanding. The range of tasks ahead spans far and wide thus requiring co-ordination and integration so that synergy is achieved and the results multiplied. Capacity-building on a prioritised list of these task activities is thus critical.

There is a need to strengthen institutional capacity for the collection and collation of data, and for further research to establish local emission factors for national GHG inventories to improve future communications. Clearly, IPCC default values for the estimation of GHG emissions are insufficient to gauge the precise extent of GHG emissions resulting from anthropogenic activities which are influenced by cultural practices and government policies. Local capacity needs to be developed to determine local emission factors for more accurate estimates. Also, the biogeochemical as well as socio-anthropogenic databases have to be developed and routinely updated, while analytical tools (such as, simulation models at the proper level of aggregation) will require development as well. Lessons from this exercise provide great opportunities to assist relevant sectors in improving their economic and environmental performance (for example, in efficiency and competitiveness).

A step in the right direction began with the preparation of this NC. The task gathered together scientists, concerned citizens, government regulators and policymakers with diverse backgrounds and representing different organisations and institutions from both the public and private sectors. Although those involved in the tasks have had many years of experience in their respective fields, most are only addressing the issue of climate change for the first time. Nevertheless, having participated in discussions and reviewed the data, there is consensus that appropriate adaptive strategies can be identified and implemented as potential first steps. Only then will it be possible to know the extent of their effectiveness. These strategic measures can then guide future actions and further refine policies in dealing with climate change issues in the country.

The various measures identified may be further expanded into project proposals which can help shape these adaptive strategies. Such projects — aimed at (1) enhancing scientific knowledge and understanding, (2) strengthening institutional capacities in terms of better database support, (3) increasing technical skills of climate change workers, (4) closer interagency collaboration, and (5) mitigating GHG emissions, are however dependent on funds and appropriate technologies being made available.

Enhancing National Capacity

Modelling Climate Change

GCMs have been around for decades. They have provided a wide range of results for understanding scenarios and outcomes resulting from climate change on a global scale. These models, however, are not at a level of resolution fine enough to show eventualities at the regional or national scale in order to adequately prepare specific nations to meet impending consequences. There is also a lack of appropriate information about the scope and extent of the problem.

The capacity of Malaysian scientists must, therefore, be enhanced to adapt, develop and run a climate model to generate relevant and localised scenarios for local use and for making short- and long-range weather predictions, as well as predictions on their impacts on the environment. For this purpose, training programmes will be required.

Database for GHG Inventories

Efforts towards mitigating the effects of climate change require an accurate inventory of GHGs on a global scale based on country inventories of GHG emissions. The Intergovernmental Panel on Climate Change (IPCC) has provided, and continually revised, guidelines for preparing inventories. As methodologies are refined, so will the need for more precise data. Technique and information should go hand in hand if the inventory preparation exercise is to be meaningful. Due to lack of a comprehensive database, however, Malaysia can only produce imprecise estimates. A critical problem faced during the preparation of the current inventory was the need to rely on IPCC default values for the various emission factors.

There is, therefore, a need to develop a proper database for a more accurate and comprehensive estimation of GHG emissions in Malaysia. Given the very different cultural and technological characteristics, the actual values for emission factors for Malaysia could be very different from IPCC default values.

There are two aspects to developing a proper database: the first involves performing laboratory and statistical analysis and supplementary testing with field data in order to obtain representative emission factors, and the second is to create a mechanism for capturing activity data on a continuing basis. To this end, several agencies and research institutions have already begun to look into ways to improve their databases. For example, in the Energy sector, MEC is currently developing Malaysia Energy Database and Information System (MEDIS) to further improve the comprehensiveness and accuracy of the energy database. Similarly, in the Land Use Change and Forestry sector, agencies such as the Regional Centre for Forest Management (RCFM) are actively carrying out activities such as the development of forest information system and the updating and upgrading of the forest inventory.

Developing the necessary database will also involve mobilising many public, as well as private, agencies. These agencies either routinely maintain records that are useful as data or are involved with activities that generate GHGs that will require close monitoring. A series of workshops will be held, aimed at creating awareness about the critical link between GHG emissions and climate change and how everyday activities produce GHGs so that systematic monitoring can be routinely carried out and reported for the purpose of updating the database. If such a mobilisation exercise is successfully systematised, GHG inventory can become an ongoing activity.

Food Sufficiency

Climate change places stress on food production. With the anticipated rise in temperature and prolonged periods of drought, land now suitable for agriculture may become marginalised. Meat production may decrease due to heat stress suffered by livestock. Many prospective measures can, however, be taken to avoid the need for additional clearing of forests to make way for increased food production in the future.

One strategy is to obtain detailed information on the supply and demand gaps from food production of different types: crops, livestock and fisheries in the country. If shortfalls occur between present production and consumption, the causes for such gaps will be identified. Suitable steps can then be made to fill these supply gaps.

A variety of research projects can help address food supply. Screening and development of plant varieties that are tolerant to high temperatures with high water use efficiency would also include trees which are used for forest plantation establishment. Animal varieties can be similarly screened to identify livestock varieties that are tolerant to high temperature stress. Apart from these it will be useful to develop precision technology that will maximise usage of water and nutrient input for crop cultivation. Developing efficient post-harvest handling of agricultural produce in view of their perishability will also be useful. Efficient housing structures that can ameliorate heat build-up could also be designed. These and other examples are prospective directions for research.

Coastal Vulnerability Index (CVI)

It has been recognised that the impact study conducted as part of the GEF-funded enabling activity suffers from the problem of aggregating impacts from project-based studies, which are located in spatially disparate areas, to the national scale. Also, previous studies had focused on certain physical parameters – such as physiographical factors (for example, shore type and form) – while usually ignoring biological and socio-economic factors. To enhance impact studies, uncertainties inherent in these studies need to be further reduced. There is a need to conduct a national mapping exercise to identify coastal areas that are susceptible to the impacts of sea level rise (SLR). This will involve the establishment of an index that will integrate all the relevant parameters and indicate the vulnerability of a locality to SLR. A national coastal vulnerability index (CVI) will be formulated and then tested/applied in several pilot sites with widely varying characteristics.

Findings from the CVI study will identify highly vulnerable areas where development should be avoided. It will serve as a basis for recommending proactive adaptive measures to mitigate the impacts of SLR.

Public Health Studies

The outbreaks of several types of diseases during recent years have presented a challenge to public health authorities. While some diseases are new, others are re-emerging. With climate change, it becomes increasingly important to examine climate change as a causal factor in the outbreak of diseases, as well as potential adaptive measures that can be taken in the prevention and handling of such diseases.

Studies need to be carried out to establish the pattern of diseases over the past decade. Alongside the diseases that are endemic to the country, emerging and re-emerging diseases will be identified and listed. Attempts will then be made to establish possible statistical causal links between the diseases listed and climatic factors based on climate data of the same time period. During analysis, a variety of potential compounding factors – such as, development, age distribution, land use change, water sources and air pollution – will also be taken into consideration.

An attempt will be made to link the incidence of diseases with climatic factors, which will test hypotheses developed to correlate the linkage between occurrences of a particular disease and climate change.

By better understanding how disease outbreaks might be connected with climate and climate change, health authorities will become better prepared to handle these outbreaks by effectively implementing and managing appropriate response actions, as well as allowing adaptive measures previously established to be modified accordingly.

Mitigation Options to Reduce CO_2 Emissions

Comparative Studies on Carbon Sequestration Potentials

Alteration of vegetation cover – for agriculture, human settlements and other purposes – has profound implications on ecosystems, biogeochemical fluxes and climate. Land cover change affects climate through factors such as albedo, evapotranspiration and emission of greenhouse and other gases into the atmosphere, through, for example, burning of biomass due to forest fires and land preparation. Changes in physical and chemical composition of the land and atmosphere, in turn, impact on the hydrological and biogeochemical cycles at global, regional and local levels.

Growing of trees and reforestation programmes help to mitigate some of these impacts. To find out to what extent reforestation and afforestation activities in Malaysia can affect CO_2 reductions in the atmosphere, a series of comparative studies will be required between the forest ecosystems and plantation forests with special reference to oil palm, rubber and *Acacia mangium*. The aim is to assess carbon dynamics in the two different forest ecosystems (primary and plantation) in order to determine the current and future carbon sequestration potentials in those ecosystems. For forest ecosystems, the studies would include the Pasoh Forest Ecosystem (lowland dipterocarp forest), hill forests which cover 70% of the total forested areas, and selectively logged-over forests under sustainable management as it is envisaged that selectively logged-over (regenerating) forests would play a major role in carbon sequestration.

The fixation volumes of CO_2 will be measured in order to estimate the carbon sink potential by the forest stands. A gap-type model will be used to simulate the flow of carbon in the forest ecosystem under the current and changing conditions for these two ecosystems being studied. The results from these studies will enable a baseline set of information to be established on potential sequestration of carbon in the two different forest ecosystems to facilitate decision making based on climate change considerations.

Energy Efficiency in the Transport Sector

Expanding urbanisation and growth in the number of private vehicles have degraded air quality due to smoke and gas emissions, including oxides of nitrogen and CO_2. Consumption of energy by the transport sector is nearly as large as that by the industrial sector. Together, they accounted for 78% of total energy consumption in Malaysia in 1997. In 1990, total registered vehicles numbered 4.5 million. By 1997, the number had nearly doubled to 8.5 million. Motorcycles and private cars are the two largest vehicle categories comprising almost 90% of total vehicles registered. According to the Road Transport Department, a total of 4.3 million motorcycles and 3.2 million cars were registered in 1997. Most are in the Klang Valley (Kuala Lumpur and Selangor). Petrol and diesel consumption in the transport sector increased from 4,715 *ktoe* in 1990 to 8,680 *ktoe* in 1997.

It is necessary to conduct a study to evaluate the energy demand and supply balance in the transport sector. Knowledge of different options in the energy balance within the transport sector and their relationship to the overall energy balance in the country will assist in the formulation of policies and strategies for achieving sustainable energy development. Currently, there is limited scope for substitution of non-petroleum fuels in the transport sector. Changing consumer behaviour, however, can also help reduce consumption. Better efficiency in the transport sector also means reduced pollution from exhaust emissions.

Biomass Waste for Power Co-generation

Along with industrialisation, agriculture will be given a boost in the country's development plans, giving rise to an increase in biomass production. Agricultural produce, however, comprises only a relatively small proportion of the total biomass that is released from cultivation. A larger proportion comes from agricultural residues that are left to rot or incinerated as waste.

Diverting unwanted agricultural residues to become energy resource supplements for use in agricultural production would reduce demand pressures on energy sources available in the country. Experiments are being conducted to develop boiler and furnace technologies that make use of agricultural residues as fuel to produce electricity in preference over more conventional diesel generators. These systems will be developed as co-generation systems that are connected to the national power grid to supplement the supply of electricity. When adopted, agricultural producers will enjoy savings in energy costs, while the reduction in the use of fossil fuels to generate electricity will have positive mitigating effects on climate change.

Many types of agricultural production may not require much power that can justify adopting a co-generation plant on-site and will, therefore, provide little incentive to agricultural producers to manage their agricultural waste. Instead the co-generation plants could be built by energy service companies and located on agricultural sites as a collaborative effort with agricultural producers. Being connected to the nation's power grid, excess power can be uploaded and retailed commercially. When fully implemented, additional power capacities coming from agriculture based co-generation plants will supplement the national power grid especially during daytime when these plants are likely to be on-line. Institutional strengthening will be necessary to operationalise this concept.

Improving Energy Efficiency in the Industrial Sector

Getting industries to become energy efficient is a win-win strategy, but manufacturing companies must be given financial and other incentives to do so. To achieve market advantage, many Malaysian companies have striven to obtain the appropriate certifications such as ISO 9002 and ISO 14000. In this connection, institutional initiatives are being considered by the government to devise an energy rating scheme to be used for certification among industrial production companies.

Devising a rating system will require undertaking a comprehensive benchmarking exercise both locally and abroad to establish site-specific as well as industry sector-specific energy utilisation baselines. Laboratory testing will also be required to identify meaningful rating standards that can become energy efficiency targets to be met by production companies.

Certification, which will be promoted as a government initiated scheme, will be made based on auditing procedures that will be devised alongside the rating and benchmarking exercises. To ensure that established targets are within reach, technical demonstration projects based on innovative power plant designs should be carried out. Data and findings will be disseminated among the industrial production community. This task will be supplemented by a programme to strengthen the capacity to fabricate energy related machinery and to undertake research and development.

The legal framework under which the energy service business is being organised is a relevant area to be reviewed. In this connection, increasing the level of participation of financial institutions in the energy business will be promoted.

Use of Photovoltaics for Electricity Generation

Based on years of experience under the Government's rural electrification programme, a new direction would be to extend the use of photovoltaics or PVs to supplement household electricity supply in urban areas and to reduce load dependency on the national grid. Electricity generated from households can also be sold to utilities, reducing the investment required for planting-up generation plants to meet peak demand. The use of PVs for household hot-water supply is already catching on in urban areas. Reducing load dependency will allow for more effective management of the nation's electricity grid, because daytime demand levels can be lowered as households switch to supply via PVs.

Demand Side Management of Energy

The nation's development and its sustainability are conditional upon continuing energy supply. Over the years, energy balance reports have been produced to monitor sources of energy and their conversion for use by broad sectors of society, including inputs and outputs of energy between domestic and offshore locations. These have allowed policy makers to track changes in energy intensities and the inter-relationship between energy requirements and socio-economic activities, as a consequence of economic expansion. They have also led to the development and management of various long-term energy resource options which are now part of the nation's energy policies.

The development and management aspects of energy demand will also be examined carefully, and industrial energy efficiency improvement is one important aspect. Beyond industrial energy efficiency improvement, the strengthening of the institutional as well as regulatory framework, promoting awareness about the importance of the demand side of energy use and looking into prospects of switching to energy saving technologies for non-industrial uses of energy, are also relevant aspects of demand side management.

The development and implementation of a Demand Side Management programme will address the problem of a very high reserve margin currently maintained by the utilities. In addition, many lessons can be learnt from experiences of other countries and adapted into appropriate measures for implementation in Malaysia.

Public Awareness Creation

The Media

The mass media represents an effective vehicle in the dissemination of information to the general public. Trained journalists can play an important role in disseminating information and educating the public about climate change issues. A strategy to heighten public awareness through the mass media is to conduct training programmes to elevate the awareness and knowledge of print and electronic media journalists on climate change issues. Much of the necessary information / material needed to create such awareness is already available from base documents generated during the preparation of this NC.

Under this programme, a series of intensive training / workshop / brainstorming sessions will be held for journalists over a six-month period in Kuala Lumpur and five other major towns across the country. As a parallel exercise within this programme, the mass media will be monitored for six months following the training in order to assess the coverage that is given to climate change-related issues. Such an assessment will help strengthen future training sessions, as well as forming the basis for future projects to create greater public awareness.

The components of this project include training of trainers, preparation of training materials, training seminars, preparation of a handbook on climate change, monitoring mass media output, holding follow-up seminars and publication of seminar proceedings.

Video Production

Although there are already many foreign-made video documentaries containing useful information on climate change for dissemination among the general viewing public, they are not geared specifically to experiences and problems directly related to Malaysia. A local production of a video documentary for distribution to the electronic mass media is to be made to supplement the efforts of the print media.

Abbreviations and Glossary

Abbreviations

ASMA	Alam Sekitar Malaysia Sdn. Bhd., a privatised environment company
ATF	Aviation Turbine Fuel
BAU	Business-As-Usual
CETDEM	Centre for Environment, Technology and Development, Malaysia
CFCs	Chloroflourocarbons
CH_4	Methane
CLICOM	Climate Computing Software
CO_2	Carbon Dioxide
COP	Conference of Parties of UNFCCC
CPI	Consumer Price Index
CVI	Coastal Vulnerability Index
DID	Department of Irrigation and Drainage, Malaysia
DOE	Department of Environment, Malaysia
EE&EC	Energy Efficiency and Energy Conservation
EFF	Efficiency-oriented
EIA	Environment Impact Assessment
ENSEARCH	Environmental Research and Management Association of Malaysia
EPU	Economic Planning Unit of the Prime Minister's Department
FMM	Federation of Malaysian Manufacturers
FRIM	Forest Research Institute of Malaysia
GCM	Global Climate Model
GCOS	Global Climate Observation System
GDP	Gross Domestic Product
GEF	Global Environmental Facility
GHG	Greenhouse Gas
GIS	Geographical lnformation System
GWP	Global Warming Potential
ICZM	Integrated Coastal Zone Management
IEEIP	Industrial Energy Efficiency Improvement Project
IGBP	International Geosphere-Biosphere Programme

IMR	Institute for Medical Research, Malaysia
IPCC	Intergovernmental Panel of Climate Change
IS92a–f	IPCC 1992 a–f emission scenarios
ISIS	Institute of Strategic and International Studies
JE	Japanese Encephalitis
ktoe	Kilo Tonnes of Oil Equivalent
LGM	Lembaga Getah Malaysia (Malaysia Rubber Board)
LOICZ	Land Ocean Interaction in Coastal Zone
MARDI	Malaysian Agricultural Research and Development Institute
MCCG	Malaysian Climate Change Group
MEC	Malaysia Energy Centre
MECM	Ministry of Energy, Communications and Multimedia, Malaysia
MEDIS	Malaysia Energy Database and Information System
MMS	Malaysian Meteorological Service
MOSTE	Ministry of Science, Technology and the Environment, Malaysia
MW	Megawatt
NAHRIM	National Hydraulic Research Institute Malaysia
NC	National Communication
NGO	Non-Governmental Organisation
N_2O	Nitrous Oxide
PET	Potential Evapotranspiration
PETRONAS	Petroliam Nasional Berhad (National Oil Corporation)
PFR	Permanent Forest Reserves
PM10	Particulate Matter of size less than 10 microns
PPI	Producer Price Index
ppm	Parts Per Million
RM	Ringgit Malaysia
SIRIM	Standards and Industrial Research Institute of Malaysia
SLR	Sea Level Rise
SPI	Sustainable Penang Initiative
START	Global Change System for Analysis, Research and Training
SARCS	Southeast Asian Regional Committee for START
TNRD	Tenaga Nasional Research and Development Sdn. Bhd.
UKM	Universiti Kebangsaan Malaysia (National University of Malaysia)
UM	Universiti Malaya (University of Malaya)
UNCED	United Nations Conference on Environment and Development

UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific, and Cultural Organisation
UNFCCC	United Nations Framework Convention on Climate Change
UPM	Universiti Putra Malaysia
USM	Universiti Sains Malaysia (University of Science, Malaysia)
WHO	World Health Organisation
WMO	World Meteorological Organisation
WOTRO	The Netherlands Foundation for the Advancement of Tropical Research

Units

cm	Centimetre
m	Metre
km	Kilometre
ha	Hectare
km^2	Square kilometre
m^3	Cubic metre
g	Gramme
kg	Kilogramme
Gg	Giga gramme
RM	Ringgit Malaysia (Malaysian Ringgit)

Conversion Units

1 Tonne	=	= 10^3 kg	= 10^6 g
1 k Tonne	= 1 Gg	= 10^6 kg	= 10^9 g
1 M Tonne	= 10^3 Gg	= 10^9 kg	= 10^{12} g

Glossary

Albedo	A measure of the reflectivity of a surface, being the ratio of the amount of radiation reflected by the surface to the amount incident upon it.
Anthropogenic	Human made. Usually used in the context of emissions that are produced as a result of human activities.
Bund	An earthen levee, sometimes reinforced on its seaward slope by rock revetment, built along the seaward edge of an agriculture development to exclude tidal water ingress into the protected area.
Coral bleaching	A phenomenon whereby corals suffer from discolouration.
Cryo-preservation	A technique of seed storage at ultra-low temperature, usually within vapour phase (–80ºC) or in liquid nitrogen (–196ºC).
Diurnal variation	The changes of value, for example, of a meteorological element within the course of a (solar) day, especially the systematic changes that occur within the average day.
ENSO	Acronym for El Nino Southern Oscillation which describes an atmospheric-oceanic phenomenon that causes seasonal fluctuations of pressure, temperature, wind and rainfall over the lower latitudes of the Pacific Ocean. It is now known to affect the climate of areas far beyond the equatorial Pacific region.
Evapotranspiration	The combined processes of evaporation from the earth's surface and transpiration from vegetation.
Genotypes	Genetic constitution or genetic make-up.
Global warming potential	A measure of the relative radiative effects of the emissions of various greenhouse gases and is defined as the cumulative radiative forcing between the present and some chosen time horizon caused by a unit mass of gas emitted now, expressed relative to that of some reference gas (CO_2 is usually used).
Groundwater recharge	Process, natural or artificial, by which water is added from outside to the zone of saturation of an aquifer, either directly or indirectly into a formation, or indirectly by way of another formation.
Insolation	The rate at which direct solar radiation incident upon a unit horizontal surface area on or above the earth's surface.

IPCC default values	These are data used in the estimation of GHG emissions and removals, based on assumptions adopted by the IPCC Expert Groups. In general, these default assumptions and data should be used only when national assumptions and data are not available.
IS92a–f	Six emission scenarios (a–f) of greenhouse gases and aerosol precursors for the period 1990–2100. They are constructed by IPCC in 1992 and embody a wide array of assumptions affecting how future emissions of greenhouse gases might evolve in the absence of climate policies beyond those already adopted.
Polder	Low-lying coastal lands reclaimed from the sea by the construction of ring levees to ward off tidal water intrusion for agriculture development.
Pumped drainage	A scheme whereby the drainage of an area is effected through lifting water to a higher elevation for discharge purposes using pumps.
Refurbishment	Retrofitting during major repair.
Saline intrusion	The upstream migration of salt water into the lower reaches of a tidal river/estuary.
Serological survey	Blood serum analysis to detect antibodies of specific infection as proof of infection.
Surface runoff	That part of precipitation that flows towards the stream on the ground surface.
Tidal gate	A water level control device using a movable gate to prevent water flowing through a channel from either direction by lowering the gate.
Water catchment	The area of land that catches rain, which then drains (surface runoff) or seeps into a stream/ river, lake or groundwater aquifer, and shares a common outlet for its surface runoff.

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Background Reports

The following are the background reports produced under the UNDP/GEF Project: Enhancement of Technical Capacity to Develop National Response Strategies to Climate Change with names of the experts involved:

1. National Climate Change Scenarios:
   Chan Ah Kee (Co-ordinator) — MMS
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2. Malaysia National Greenhouse Gas Inventory 1994:
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