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Whither the Weather?

Recognising the Impacts of Climate Change

Distinguishing Weather from Climate

Climate is what you expect; weather is what you get.

Weather is a set of all the phenomena occurring in a given atmosphere at a given time. It refers to current activity, as opposed to the term 'Climate', which refers to the average atmospheric conditions over longer periods of time.

Definition offered by the Intergovernmental Panel on Climate Change (IPCC)

Climate, in a narrow sense, is usually defined as the average weather, or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period of time ranging from months to thousands or millions of years. The classical period is 30 years, as defined by the World Meteorological Organization (WMO). These quantities are most often surface variables such as temperature, precipitation and wind.

Climate Change

The Earth has undergone periodic climate shifts in the past, including four major ice ages. Such ice ages were essentially glacial periods where the conditions were colder than normal, separated by geological intervals of warmer global temperatures (Fig 1).

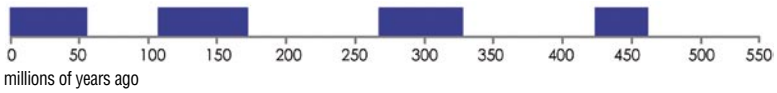

Figure 1: Major long-term cold periods over the last ½ billion years.
Source: Climate Change and Human Evolution.
http://anthro.palomar.edu/homo/homo_3.htm

In what is popularly termed as the 'greenhouse effect' (Fig 2), greenhouse gases, such as carbon dioxide, methane, nitrous oxide, ozone, sulfur hexafluoride, hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs), in the Earth's atmosphere, effectively absorb thermal infrared radiation, emitted by the Earth's surface. These radiations are re-emitted to all sides, including downward to the Earth's surface by the greenhouse gas molecules, thus warming the Earth's surface and the lower atmosphere. According to scientific research, climates are changing because our Earth is warming.

In recent usage, the term climate change often refers to changes in our climate which have been identified since the early part of the 1900s. The changes seen over recent years and those which are predicted for the next 80 years are thought to be mainly a result of human behaviour rather than to natural changes in the atmosphere.

Greenhouse gas emissions arising from human activities, primarily through the widespread use of fossil fuels, are believed to be a major contributor to the rise in average surface temperature of the Earth.

Before the start of the Industrial Revolution, the levels of carbon dioxide in the atmosphere were about 280 parts per million by volume (ppmv). Current levels are about 370 ppmv. The concentration of carbon dioxide and other key greenhouse gases in our atmosphere today is higher than at any time in the past 650,000 years, and probably higher than in the past 20 million years. The IPCC predicts that by the end of the 21st century, we could expect to see carbon dioxide concentrations of between 490 ppmv to 1260 ppmv.

The other major cause of global warming is believed to be deforestation. Deforestation is said to be blamed for 25% of all carbon dioxide entering the atmosphere, by the cutting and burning of about 34 million acres of trees each year. Trees collect the carbon dioxide that we breathe out and give away from various other sources, and they give back oxygen that we breathe in. Thus, cutting of trees will lead to greater concentrations of carbon dioxide in the atmosphere.

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From the desk of the Director General

Whither the Weather?

It is only over the past five years or so that all of us have awakened to the climate issue. Climate change and the environment have emerged as a serious concern with all fingers pointing to the high levels of greenhouse gas emissions as the underlying cause of climate change. There is no other alternative except for both the developed and the developing world to 'gang up' and take action together to save Mother Earth.

Climate is generally taken to mean an average of weather conditions over a long period of time. Say, something like millions of years. Herein lays the central difficulty of getting people and nations to act to save the environment. We live short, economic lives as individuals whilst the environmental life of plants and animal species on this Earth is a 'million-year-old' saga of weather and wither! We fail to understand the grand time scale of Nature, its delicate mystery and its astounding beauty.

Over the past 500 millions of years, the Earth has undergone periodic climate shifts including four major ice ages running into millions of years. These ice ages were glacial in nature. Weather conditions were colder than in the past. These ice ages were separated by geological intervals of yet more millions of years of relatively warmer weather. Within these mega cycles were smaller cycles of glacial periods and anti-glacial periods alternating over intervals of 100-150 thousand years. To comprehend fully the scale of the earth's workings is indeed daunting. The ebb and flow of these cycles are truly monumental. So climate has always changed. Why should we be concerned now?

It is because, scientists studying the past (Vostok ice cores) and the present now have enough evidence to believe that the Earth's climate system is evolving into a path different from the past natural cycles. Their conclusion is sobering: climate changes seen over recent years and those predicted over the next 80 years are mainly the result of human behaviour rather than natural cycles and rhythms. Clearly, say the scientists, we are singing out of tune with the rest of Nature and its natural cycles. And because of that, instead of the Earth evolving into the cold conditions of another glacial period, the climate system is heading for an un-natural and unprecedented warmer period. And it is largely of our doing. Hence the term to describe this phenomenon - anthropogenic global warming. Or in other words we should be crying in shame instead of singing in the rain!

Nature makes regular trips called cycles. And all the signs tell us, that on Nature's next trip, we on Earth are going to feel really warm. We must remember, environmental time is vastly different from economic time. The current concentrations of carbon dioxide (CO_2), methane (CH_4) and other greenhouse gases are pushing us towards global warming levels that will be outside the realm of human existence. A 5°C increase in mean surface temperature will surely spell disaster for many of Earth's plant and animal species. Neither the simple nor the complex organism will be spared. The dramatic evidence of this is the current levels of bleached coral around the world.

We are all going to face the heat as well as the wet. Let us take a weather snapshot – say July 2008: Hurricane Dolly wreaks havoc in Mexico and Central America; severe storms hit Norway and northeastern USA; unseasonal flooding in Eastern Europe, South Africa, South Korea and western Japan ; massive monsoonal flooding in northern India, Nepal and Bangladesh and typhoons wreak havoc in southern China. The damaging effects of such extreme weather patterns are disturbing natural environments around the world. We can expect much of the same and more – volcanic eruptions, El Nino, glacial melting, sea level rises, polar ice cap reduction and melting permafrost. Such weather changes will directly contribute to the geographic re-distribution of vector diseases such as malaria and cholera. Crop yields will show new patterns of ups and downs with the resultant potential for conflict, famine and migration. Droughts, severe weather conditions and disasters, food shortages, diseases and rising sea levels will result in massive population displacement and migration.

A gloomy and frightening scenario indeed! Malaysia like all other nations has to take action as an imperative. If we are to go by the compelling figures that current climate science offers, global greenhouse gas emissions should ideally decrease from the current levels by 90% by 2050 in order to contain global warming by 2 °C. We must take mitigative action to stop further increases in greenhouse gas emissions. The shift to a low carbon economy is inevitable and businesses must get ready to get into it especially in energy, transport and heavy industry. Secondly, though we are still a developing country, we have to resort to technology to solve our environmental problems.

Climate change is already high in the minds of society. Climate change issues do not concern only the government. It is society, you and me, that must play our role in reducing greenhouse gas emissions. For all the nations and peoples of the world, failure is inconceivable. We must weather the storm of climate change!

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Greater urbanisation, the demand for land for factories, housing and other buildings, and timber for construction, are all reasons leading to deforestation.

The predicted effects of global warming, on the environment and for human life, are numerous, varied and still so many that are yet to be discerned. It is generally difficult to attribute specific natural phenomena to long-term causes, but some effects of recent climate change may already be occurring. Rising temperatures on Earth have already resulted in ice shelfs melting, breaking off at the poles, glacier retreats and more extreme weather conditions around the world. Some islands in the Pacific, such as Tuvalu are already experiencing severe flooding that is damaging homes and affecting drinking water supplies. Some islanders have already started to leave!

There are droughts in places that enjoyed good rainfall earlier. In July 2008, above average temperatures were observed across Japan, the British Isles, northwestern Africa, the northwestern and northeastern continental US and most of South America, Europe, Australia and Asia. Meanwhile, cooler-than-average conditions were present across far northwestern Europe, the southern and western coasts of Alaska, north-central Russia, parts of the north-central contiguous US, Mexico and southeastern China.

Such surface temperature differences in turn cause pressure differences where small changes in one part of the system can grow to have large effects on the system as a whole. This is seen in terms of some of the harsh cyclones and thunderstorms in recent times (Fig 3). Frequent extreme weather events mean more potential deaths and injuries caused by storms and floods.

Damaging effects of such extreme weather patterns are also disturbing natural environments around the world. This is being manifested through variations in the biological systems essentially the crops, forests, oceans, fresh waterways and grasslands. As these are the building and breeding grounds of life, life on Earth is being affected. Global warming is being blamed for the extinction of various species. Major changes are seen in animals as they react to the warmer environment. Studies show that animals are beginning to shift their population towards the colder north or towards higher altitudes. Some animals have become extinct due to loss of their natural habitat or their inability to evolve to the rapid changes in the climate. Also, there is a change in their life style because of the changes in the seasons. Some migrating birds have changed their time of travel and also their place of migration.

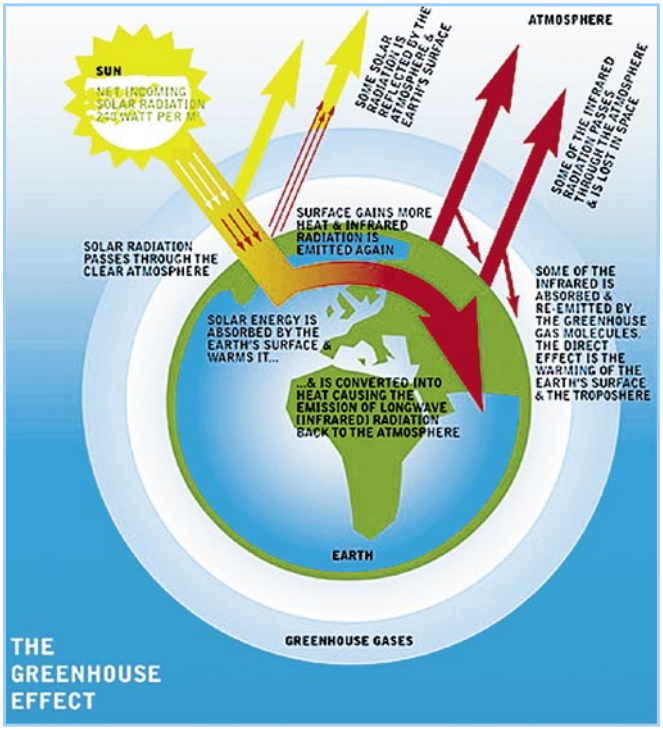

Figure 2: Contribution of 'greenhouse effect' to global warming. *Source*: http://www.greenpeace.org/international/photosvideos/photos/greenhouse_effect

Climate change is also thought to directly contribute to changes in the geographic distribution of vector-borne diseases such as malaria and epidemics of meningococcal meningitis, for instance, Rift Valley fever and cholera in previously unaffected areas. It is also expected that the intensity and seasonality of many vector-borne and other infectious diseases will be altered. In general, increased warmth and moisture would enhance transmission of vector-borne diseases. However, it should be noted that any such climate-related redistribution of disease may also entail, some localised reductions in rates of infection.

Climate change disasters are becoming a bigger cause of population displacement than war and persecution. Experts say a third of Bangladesh's coastline could be flooded if the sea rises one meter in the next 50 years, causing about 20 million citizens to be displaced from their homes and farms. This is about the same as Australia's population. Droughts, severe weather, food shortages, diseases, and rising sea level are expected to drive migration around the globe creating potential impacts for international security.

As climate change and agriculture are interrelated processes, altered patterns of agriculture can be expected as a direct consequence of climate change. For example, the average crop yield could drop by 50% in Pakistan, whereas corn production in Europe could grow by 25% because of optimum hydrologic conditions.

Global warming is projected to have significant impacts on conditions affecting agriculture, such as temperature, precipitation and glacial run-off. The carrying capacity of the biosphere to produce enough food for the human population and domesticated animals is determined by these conditions. An increase in carbon dioxide levels could result in effects that are both detrimental and beneficial to crop yields. For instance, agricultural yield could substantially decline due to higher temperatures, increased drought, spread of diseases, invasion of weeds and destruction of soil nutrients. It is believed that developing countries which already have high temperatures will be most affected with low agricultural productivity. Conversely, food production in northern countries, especially in industrialised nations, could increase due to the effects of global warming increasing the length of

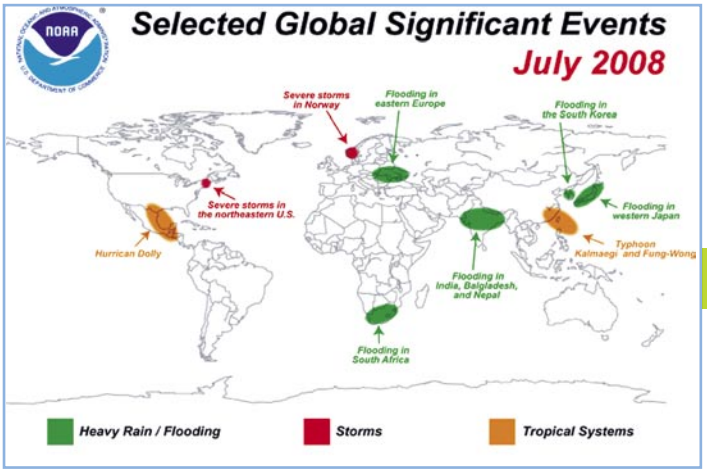

Figure 3: Some of the global hazards and significant events in July 2008.
Source: National Climatic Data Center, U.S. Dept. of Commerce.

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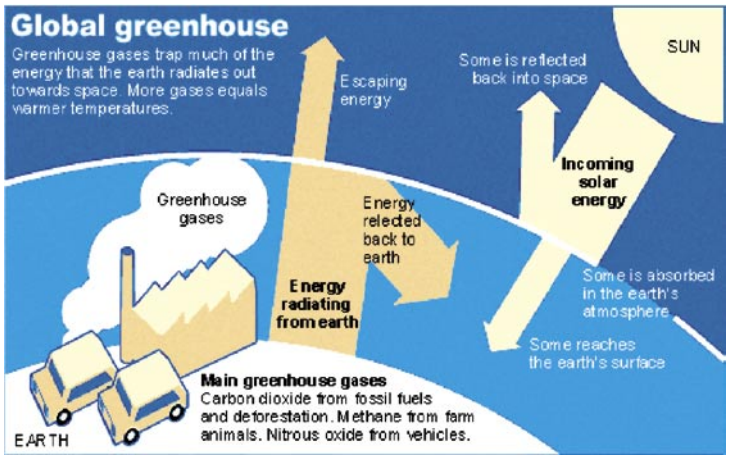
Insights into Climate Change

That the climate is changing is unequivocal. This is essentially the very important conclusion in the Fourth Assessment Report (AR4) of the Intergovernmental Panel on Climate Change (IPCC), released in February 2007. Indeed, the IPCC played an important role in raising awareness on the climate change issue. Climate change has been singled out as the most important issue affecting humanity. For this contribution, the IPCC, together with Al Gore, the former Vice President of the US, were awarded the Nobel Peace Prize in December 2007.



Greenhouse Gases and Global Warming

Why should we be so concerned about current climate change if we know that the Earth's climate has been swinging from 'glacial' to 'anti-glacial' periods almost regularly at time intervals of 100-150 thousand years. The famous Vostok ice core that logs the history of Earth's climate for the last 420,000 years revealed that the Earth has been experiencing several alternating glacial and anti-glacial period over this long era (Petit *et al.* 1999). This is pretty much due to the cycle of the Earth's orbit around the sun known as the Milankovitch Cycle.

From about 10,000 years ago, the Earth has been in the inter-glacial period. Interestingly, through tiny bubbles trapped in the ice core, the scientists also managed to estimate the level of carbon dioxde (CO_2) and methane (CH_4) gases during the period. Obviously, the concentration levels of CO_2 and CH_4 in the atmosphere fluctuated in tandem with the ups and downs of the air temperatures during the period. However, throughout the 420,000-year period, the CO_2 concentration had never exceeded 300 ppm. The current CO_2 concentration level of more than 380 ppm has far exceeded the highest level of the inter-glacial period of 420,000 years ago.

Similarly, the current CH_4 concentration of more than 1774 ppb has far exceeded the highest concentration during that period. The trend of rapidly increasing concentration levels of CO_2, CH_4 and other greenhouse gases (GHGs) since the pre-industrial era, particularly the sharp increase in the mid-1950s, was primarily due to the burning of fossil fuels, and agricultural and industrial practices.

In fact if the current rate of emission remains, the doubling of the pre-industrial level of CO_2 (280 ppm) would be achieved between 2030 – 2050. If this is reached, the Earth will likely commit global mean temperature increases of between 2 – 5˚C. A warming of 5˚C on a global scale would be outside the experience of human civilisation. By 2100, the CO_2 concentration would be triple the pre-industrial level and this would likely commit the earth to warming of 3-10˚C (Stern Review, 2006).

Many scientists believe that the climate system is evolving into a path, different from the past 420,000 years. Instead of evolving into a cold condition of another glacial period, the climate system is heading for an unprecedented warm period. Scientists believe the present inter-glacial period is long over-due for it to evolve into the next glacial period but with the presence of anthropogenic global warming, the transition is unlikely to materialise.

Energy Balance of the Earth's Climate System

For an insight of why the increasing concentration of GHGs in the atmosphere can lead to global warming, one needs to understand the energy balance of the Earth's climate system. The Earth has five interacting components namely atmosphere, hydrosphere, biosphere, geosphere and cryosphere. The system, due to the multiscale interactions between the components, exhibits natural variability from weather time scales to decade or even century climate time scales. The system receives its energy from the sun that radiates shortwave radiation to the Earth's surface through the atmosphere. The presence of GHG in the atmosphere acts like a 'blanket' to the Earth to keep it warm and suitable for life to flourish. This is the commonly mentioned greenhouse effect. However, too much of GHGs is detrimental to the Earth's climate system as back longwave radiation from the surface of the Earth will not be able to escape. As a result, over time, the Earth's temperature will rise. Most of the extra heat, that is about 85%, is essentially absorbed by the ocean resulting in ocean warming, that can be traced up to depths of 3000 metres.

Consequences of Ocean Warming

Ocean warming has greater consequences - it influences the weather and climate. Naturally, due to high heat capacity of water, the ocean acts as a 'heat engine' to the climate system. Oceans distribute heat polewards from low latitudes through networks of surface and thermohaline circulations. Distribution of heat by the ocean is important in maintaining the climate at any location on Earth. For example, Europe would be much colder during winter if it is not because of the heat transported by the "Ocean Conveyer Belt" northward from low latitudes to the region of north Atltantic ocean and Labrador Sea. Similarly, major western boundary currents such as the Gulf Stream and Kuroshio, are responsible for transporting excess heat northward.

The oceans perform other roles besides transporting heat poleward. They also influence the atmospheric circulations, determine regions of convection and hence largely influence how moisture is transported and distributed over land. Interaction between ocean and atmosphere results in phenomena such as the El Nino-Southern Oscillation (ENSO), Indian Ocean Dipole (IOD) and Madden-Julian Oscillation (MJO). These phenomena in turn can cause variations in the climate system by altering the usual seasonal cycle.

By definition, climate is an average of weather conditions over a long period. Hence, when climate varies or changes, weather conditions also vary or change. During the summer season, when the ocean surface is anomalously warmer, tropical storms may develop. However, for the last 100 years or so, the increase in global mean temperature has only been less than a degree celsius. Nevertheless, with that amount of warming, we are already experiencing record breaking droughts, floods, tropical storms and heat waves. Imagine the kind of climate and weather conditions we will face when the global mean temperature reaches 2-5˚C by 2030-2050 or 3-10˚C by 2100.

Source: Environmental Protection Agency

Due to the heat absorbed by the ocean, its circulation and the way it influences atmospheric circulation may be very different from today. Large amounts of energy in the ocean could mean much more intense and powerful tropical storms. Likewise, the characteristics of natural phenomena such as ENSO, IOD and MJO could be altered. For Malaysia, enchancement of these phenomena could mean more extreme floods and extreme droughts and haze epsiodes. The extreme flood in Johor that occurred from December 2006 to January 2007 was associated with these phenomena and a severe monsoon season (Tangang *et al.* 2008).

For some nations particularly in temperate regions, higher temperature could mean greater potential for enhanced agricultural outputs. However, for regions where floods, droughts and tropical storms are experienced, intensity and severity may be enhanced or in coastal regions, a sea level rise can pose serious problems. Climate change may mean devastation and destruction of homes, properties, crops and even loss of lives. The recent sequence of four hurricanes that hit Haiti within a month serves as a reminder that it is the poor nations that are going to be affected most by climate change. Cyclone Nagris that created havoc in Myanmar in May 2008 is another example of extreme weather. Similarly, the recent floods in Bihar, India is another example of the consequences of climate change. Malaysia itself is not immune to this problem. In countries or regions where vulnerability is high, there is not much choice other than to adapt to catastrophes brought by climate change.

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the growing season. Overall, the prediction is for agricultural productivity for the whole world to decline by 3-16% by the 2080s as a consequence of global warming. The damages are expected to deepen in the following century in the face of still greater warming.

Marine life is also not spared from global temperature increases. Rising global temperatures will adversely impact the stratification of the ocean's surface, causing changes to the surface water light regime and nutrient input from deeper layers of the ocean. These changes have far-reaching implications for the whole ecosystem and food chain.

The effect of global warming will certainly be seen on some marine species. It is expected that many species will die off or become extinct due to the increase in water temperatures whereas various other species, which prefer warmer waters, will increase tremendously. Perhaps the most disturbing changes are expected in the coral reefs because corals are extremely sensitive to temperature changes and can undergo mass coral bleaching under heat stress.

A Global Challenge that Requires Global Action

Broadly, we need to take two actions, soon and as effectively as possible: mitigate the increase in greenhouse gas emissions and help, particularly the developing countries, adapt to the already inevitable effects of climate change.

At the core of most mitigation proposals is the reduction in greenhouse gas emissions through reducing energy use by way of higher fuel-efficient systems, and switching to cleaner energy sources such as hydrogen fuel cells, solar power, tidal and ocean energy, geothermal power and wind power.

Adaptation refers to initiatives and measures to reduce the vulnerability of natural and human systems against actual or expected climate change effects. Examples of adaptation include technological solutions for coastal defenses and changing patterns of land use like avoiding more vulnerable areas for housing, better irrigation systems, rainwater collection and storage, damming of glaciers, cultivating drought-tolerant crops in areas where rainfall is becoming less and sustainability considerations.

While most national governments have signed and ratified the Kyoto Protocol aimed at reducing greenhouse gas emissions, there is still ongoing political and public debate worldwide regarding what, if any, action should be taken to reduce or reverse future warming or to adapt to its expected consequences.

The global challenge is here and it requires effective global action. Be it mitigation or adaptation, the investment will be substantial, but the cost of doing nothing will be far greater. We have the responsibility to leave this world cleaner and safer for generations to come. Working to save our future generations from the worst effects of climate change is something that many would agree is worth our effort.

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Climate Change and Agricultural Development: The Need for a Policy Framework

A significant outcome of the recent APEC summit was the Sydney Declaration on climate change, though there were some disagreements on the resolutions between developing and developed economies. Nonetheless, the issue was worth discussing.

Climate change poses challenges for all sectors of the Malaysian economy, but particularly those sectors dependent on natural resources such as agriculture and forestry. Despite technological advances in biotechnology, climate is still a key factor in determining agricultural productivity.

Agriculture and climate are mutually dependent. Their interactions involve temperature effects, water supply and demand, and fluxes of carbon through the processes of photosynthesis and respiration. Emissions from agricultural sources are believed to account for some 15% of today's anthropogenic greenhouse gas (GHG) emissions.

Climate also affects the crop pests and predators. Climate is important not only in terms of average conditions, but also in regard to the frequency and intensity of extreme events, such as floods, droughts, and heat spells. For example, a recent flood in Johor has resulted in losses of agricultural production worth millions of Ringgit. A study by Universiti Putra Malaysia (UPM) in Muda Agricultural and Development Authority (MADA) indicated that tropospheric O_3 is increasing and above the Ozone Threshold of 40 ppb (AOT40) cases during the growing period of year 2003 and 2004, and this significantly reduced the rice yield to 12%.

Despite general uncertainties, studies have consistently shown that overall production in the mid and high latitudes is likely to benefit in the near term (approximately to mid-century), while production systems in the low-latitudes are likely to decline. This finding has implications for world food security, since most developing countries, including Malaysia, are located in lower latitude regions. The vulnerability of developing countries is related to the growth of crops under current climate conditions nearer their optimum temperature limits and the potential for greater increases in water stress under a warming climate. Developing countries also have fewer resources for development of appropriate adaptation measures to counter negative impacts.

There is a general agreement that the long-term effects on agriculture are negative. If climate change effects are not abated, agricultural production in the mid and high latitudes is likely to decline in the long term (approximately by the end of 21st century). They are due primarily to detrimental effects of heat and water stress on crop growth as temperatures rise.

Malaysia, being a food deficit country with an import bill of RM15.4 billion in 2005, a policy framework that deals with the effect of climate change on her agricultural development is crucial. This framework is needed to provide practical tools to develop effective and efficient policies to deal with climate change challenges. Some possible areas in the framework include adaptation strategies to build resilience into production systems; mitigation strategies to reduce or offset greenhouse gas emissions; research and development strategies to enhance the agricultural sector's capacity to respond to climate change; and awareness and communication strategies for inform decision making by agricultural producers.

Mitigation strategies – such as carbon sequestration in agricultural soils – are aimed at reducing the atmospheric concentration of CO_2 and other greenhouse gases, thereby countering climatic change. Adaptation strategies, such as changes in crop types and management practices, are responses that optimise production under changing climate conditions.

Mitigation and adaptation responses are synergistic. Mitigation practices can enhance the adaptation potential of agricultural systems. For example, carbon sequestration in agricultural soils leads to more stable soil-water dynamics, enhancing the ability of crops to withstand drought and floods, both of which may increase under changing climate conditions. In addition, many of the strategies proposed for reduction of GHG emissions from agriculture are 'best practices', that is, they increase input efficiency while limiting environmental damage. For instance, use of tree shelterbelts can help to minimise soil erosion and stabilise soil carbon; mulches added between row crops help to conserve soil water, reduce erosion, and sequester carbon. Recent studies have shown that improved agriculture practices can significantly help in reducing the emissions of carbon dioxide by increasing carbon sequestration.

The potential contribution of the agricultural sector in the reduction of GHG emissions by sources and removals by sinks in the agriculture soils largely depend on the farmers' adoption of environmentally friendly land use and management practices. Farmers' decision on adoption of these practices that result in additional carbon sequestration in particular ecological settings, are largely influenced by the net returns from the farm and existing agriculture and environmental policies. Although adoption of these practices by farmers also creates on-farm benefits such as increased crop yields, adoption of these practices in a wider scale largely depends on to what extent farmers are compensated for the additional global benefits and taxed for the negative externalities they generate from their local activities. Farmers may need additional knowledge and resources for investing in such practices. Farmers' decision on land allocation for different purposes and their shift towards adoption of land management practices, on the other hand, are also largely influenced by the existing economy-wide policies, and strategies such as investment in research on soil fertility management, provision of required infrastructure and market facilities.

Agricultural soils can be both a contributor to and a recipient of the effects of a changing climate. In the past, land management has generally resulted in considerable depletion of soil organic matter and the release of carbon dioxide. Now, there is the potential to restore soil organic carbon through improved management techniques, enhancing soil structure and fertility and helping to counter climate change. An important caveat is that the capacity for agricultural soil carbon sequestration is constrained by the amount of carbon lost during the conversion of natural ecosystems to agriculture, so that its effectiveness as a mitigating activity for climate change is not unlimited.

In conclusion, a policy framework that deals with the planning and implementation of mitigation and adaptation measures in response to the global climate change issue should be coordinated and implemented together. Investments in research and development programmes will be needed to assure effectiveness in both adaptation and mitigation activities for the Malaysian agriculture sector. This needs to be explicitly addressed in the Malaysian Agricultural Policy.

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Effects of Climate Change on Coral Reef Ecosystems

Figure 1: Bleached corals on the Great Barrier Reef. *Photo:* Ray Berkelmans, Australian Institute of Marine Science in Gabriel and Rodney, 2005.

Coral reefs represent one of the most biologically diverse ecosystems on Earth. They occur in a variety of fringing, barrier, and atoll settings throughout the tropical and subtropical settings worldwide. Coral reefs constitute important and productive source of biodiversity, besides contributing economically through tourism activities. Tourism, based on natural environment, especially islands and shores with coral reef ecosystems, has been increasingly gaining importance in many national economies, generating revenue worth billions of dollars annually around the world. In addition, coral reefs serve as important habitat for fishes, besides protecting coastlines by reducing wave actions.

However, coral reefs are under assault from a multitude of sources around the world. Depending on their location, reefs have been damaged directly through harmful practices such as overfishing, application of destructive fishing methods, haphazard coastal development, as well as by irresponsible behaviour of tourists. Reefs have also suffered indirectly from sediment flows into the sea due to excessive coastal development, nutrient pollution from sewage discharges and other effluents from land, as well as from marine-based pollution such as oil and grease. Nevertheless, human activities have been identified as one of the main reasons for the degradation of this ecosystem. These local factors, together with episodic natural events such as storms, are regarded as some of the major primary causes of coral reef degradation in the past.

However recently, climate change has been categorised as one of the leading factors for depletion of these important resources in many parts of the world. With the increased focus on the impact of climate change, scientists claim that the world's coral reefs are under threat from increasing sea temperatures. As such, it can be foreseen that humans and industries or sectors dependent on this important fragile ecosystem, such as the tourism sector, would also be likewise impacted in the long run. Indirectly, this would impact the country's economy and foreign exchange negatively. As such, this article highlights some of the effects faced by the coral reef ecosystems globally due to climate change, and briefly examines the situation in Malaysia.

Coral Reef Ecosystems

Coral reefs are composed mainly of colonial animals (polyps) that live symbiotically with single celled microalgae (zoozanthellae) in their body tissue. Basically, zoozanthellae are photosynthetic algae living in corals' tissues, giving corals their bright coloration. The coral provides shelter for the algae, which in turn provide food, oxygen and nutrients for the coral. Coral reefs are formed by hundreds of thousands of polyps and are normally found in warm, shallow, clear, low nutrient tropical and sub-tropical waters, with optimum temperatures of 25-29˚C. However, they may also exist in temperature ranging from 18˚C (in Florida) to 33˚C (in the Persian Gulf). Higher than normal temperatures force corals to expel the zoozanthellae living in the coral polyps, leaving behind white calcium skeletons. Based on literature, elevated sea temperature has been identified as the major stress factor associated with coral bleaching. However, other additional stresses such as high light intensity, low salinity and pollutants have also been recognised as contributing to worsening coral bleaching phenomenon worldwide. If the causal stress is too great or for too long, affected corals would eventually die. For example, Figure 1 shows coral reef bleaching at the Great Barrier Reef, Australia leaving the corals in pale colouring.

A major coral reef bleaching phenomenon at the global level was caused by El Nino in 1997-98, affecting large areas of coral cover globally (refer to Figure 2). Following that, the losses to reef-dependent tourism caused by the impacts of mass bleaching around the world were enormous. Some estimates of economic losses at some of the world's popular tourism/diving destinations touched millions of dollars. For example, Zanzibar experienced USD3-4.6 million in financial losses, Mombasa, USD13-20 million, Maldives, USD3 million, Sri Lanka, USD0.02 million and Philippines USD15 million loss in net revenue to the economy and further losses of USD350,000 to the diving industry in Palau following the bleaching event caused by El Nino.

Based on various studies, the summary of some of the likely impacts of climate change on the coral reef ecosystems are listed in Table 1. This demands the adoption of environmental management strategies to ensure continuous sustainability of the coral reef ecosystems for human benefit.

The Coral Reef Situation in Malaysia

Malaysia's coral reefs extend from the 'Coral Triangle' connecting it with Indonesia, Philippines, Papua New Guinea and Australia. There are mostly shallow fringing reefs at the offshore islands of Malaysia; although patch reef, coral atoll and barrier reefs are also available, they appear on a smaller scale. The United Nations Environment Programme (UNEP) World Atlas of Coral Reef had estimated that the size of the coral reef areas

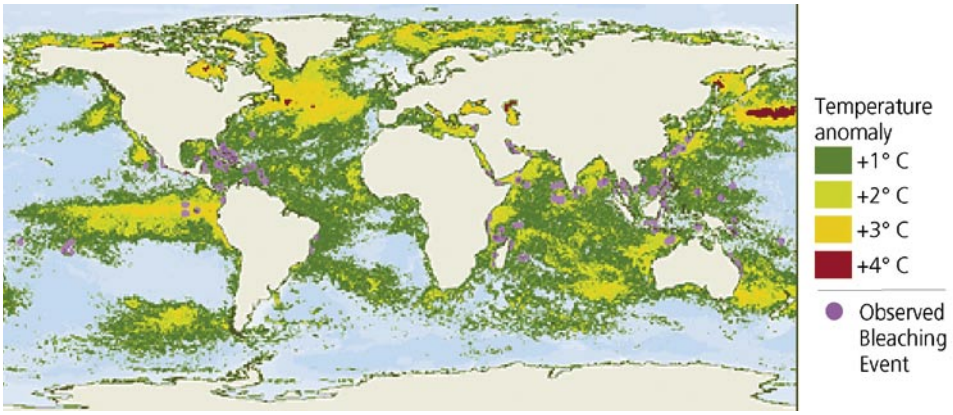

Figure 2: Coral bleaching events and sea surface temperature anomaly hot spots, 1997-1998.
Source: World Resources Institute (http://earthtrends.wri.org/maps_spatial/maps_detail_static.php?map_select=207&theme=1)

Table 1: Likely impacts of climate change on the coral reef ecosystems.

Direct / indirect impacts of climate change	Effect
Increases in ocean temperatures	Cause increase in coral beaching (whitening) by disruption of the symbiotic relationship between polyps and zooxanthellae. This would result in the expulsion of zooxanthellae and loss of photosynthetic pigments, leaving the corals whitish in colour. If stresses continue long enough, corals can suffer reduced fecundity and growth rates, and eventually die off.
Increases in the atmospheric concentrations caused by green house gases release, especially carbon dioxide (CO_2)	This phenomenon could effect changes in surface ocean chemistry. In essence, increased absorption of carbon dioxide into the oceans increases acidity, which lowers the ability of corals to generate their skeletons. Acidification causes harm to the ocean plants and animals that build shells of calcium carbonate- including many tropical reef building corals. As such, coral calcification would decline due to the direct influence of CO_2 on sea water chemistry.
Raising world sea levels	This would result in less light reaching deeper corals, thus threatening the zooxanthellae as they require light for the photosynthesis process to take place. This has a more significant effect on the degradation of coral reef ecosystems as a whole.
Effects of climate change when combined with more localised stresses	Effects of climate change, when combined with other localised stresses such as pollution, sedimentation, and destructive fishing methods could augment coral reef depletion.

in Malaysia is about 3,600 km^2 or 1.27 % of the world's total coverage. In addition to fisheries, coral reefs in Malaysia provide many other exceptionally valuable services. For example, their beauty draws thousands of tourists from around the world each year, generating much economic revenue for the country. Furthermore, corals themselves possess a yet untold value as biochemical material for pharmaceuticals and other products for the country.

The more transparent coral reefs management strategy in the country is the adoption of Marine Parks. To date, there are 42 marine park islands located in Peninsular Malaysia and Labuan alone, not including the parks in Sabah and Sarawak. Annually, about half a million tourists are recorded visiting our marine parks which are rich with coral reefs.

Unfortunately, according to Reefs at Risk (2002), 85% of the reefs of Malaysia are threatened by human activities. These include impacts from coastal development activities, pollution, and unsustainable tourism practices, to name a few. To add to the list, climate change has been increasingly identified as another cause of reef degradation in Malaysia in recent years. However, limited information and research has been carried out in the country on the extent of the impact of climate change on coral reefs.

However, one recent researches was carried out by the Marine Ecosystem Research Centre (EKOMAR-UKM) in July 2008 at the Renggis Island. Renggis Island is a favourite destination among snorkelers and divers visiting the Tioman Island Marine Park situated off Mersing. The quick survey undertaken showed the extent of coral reefs bleaching around the Renggis Island (see Figure 3). Coral bleaching is occurring at a depth of around 1-1.5 metres, although there were also indications that deeper areas have started to show signs of coral bleaching as well. This demonstrates that climate change has also taken a toll on the coral reefs in the country.

Charting the Way Forward

Overall, it is apparent that climate change has not only affected coral reefs globally, but also poses a significant threat to the fragile ecosystem in Malaysia. From a management point of view, the degradation of reefs is mainly related to insufficient information on climate change impacts on the reefs in the country, poor management of other existing threats (that is, pollution, sediment release into the coastal waters from excessive development, irresponsible tourist behaviour, and destructive fishing pressure from fishermen), as well as inadequate institutional capacity (lack of experts or personnel). All these factors complement one another and cannot be treated in isolation when dealing with management interventions.

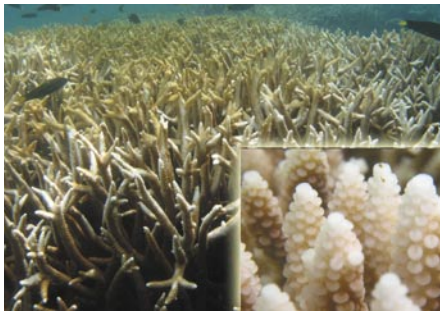

Figure 3: Photo taken on 8 July 2008 showing bleached corals at the Renggis Island, Tioman Marine Park. The closer view illustrates the expulsions of zooxanthellae causing the polyps to look whitish in colour.
Source: Kee Alfian / Marine Ecosystem Research Centre (EKOMAR-UKM).

As such, it is important to document the vastness of the effect and keep track of the affected areas, both through scientific understanding as well as management interventions. This warrants more surveys in order to assess the extent of the bleaching event for the formulation of better management interventions. For example, on detection of the phenomenon, affected areas could be closed or opened to very limited activities to reduce pressure from other stresses on the reefs. Some of the possible recommendations include:

- The conduct of long-term monitoring programmes and research in order to understand the underlying causes of coral bleaching, which could be carried out by experts from the local universities in cooperation with related agencies (i.e. Department of Marine Parks Malaysia).
- Develop a better knowledge base on the connectivity of reef systems to better understand the process of coral recruitment and reef recovery after bleaching, including a better appreciation of the time scales necessary for regeneration. This could be adapted to develop site specific management plans for reef rehabilitations.
- While attempts to adapt to changes may represent one response to the projected climate impacts, immediate action must also be taken to reduce greenhouse gas emissions, if coral reefs are to have any future at all.

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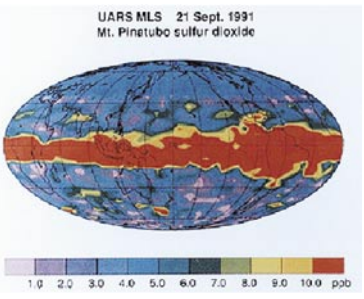
Satellite Imaging for Monitoring Global Climate Change

'Global climate change', 'greenhouse effect' and 'global warming' are hot topics that are being discussed by scientists around the world. Climate scientists recently issued a warning on global warming, prompting a UN demand for politicians to tackle the global warming crisis. Global average surface temperatures could rise between 1.1°C (1.98 °F) and 6.4°C (11.52 °F) compared to 1980-99 levels. Sea levels will rise by at least 18 centimetres (7.2 inches). Heat waves, rainstorms, tropical cyclones and surges in sea level are among the events expected to become more frequent, more widespread or more intense this century.

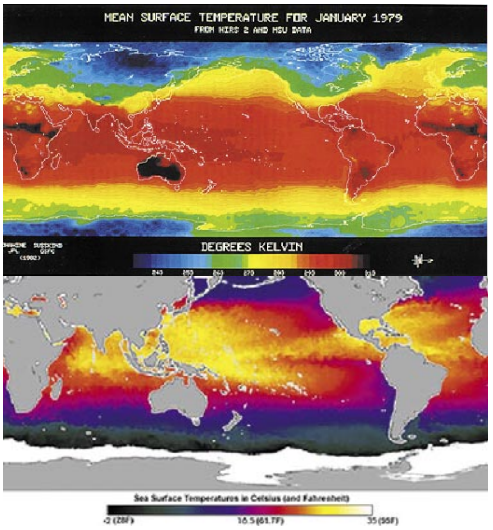
The extent of these climate changes has prompted concern about the possible effects on the global physical, chemical and biological systems. Land use change is frequently accompanied by alterations or changes in land cover, which may possibly contribute to subsequent environmental change. Satellite images may allow the types of change to be regionalised and the proximate sources of change to be identified or inferred. Such satellite information, combined with results of case studies or surveys, can provide helpful input to informed evaluations of interactions among the various driving forces. Satellite images can be used in monitoring several phenomenan related to global climate changes such as volcano eruption and El Nino, increased earth temperature, ozone layer depletion as well as glacier melting and sea level rise.

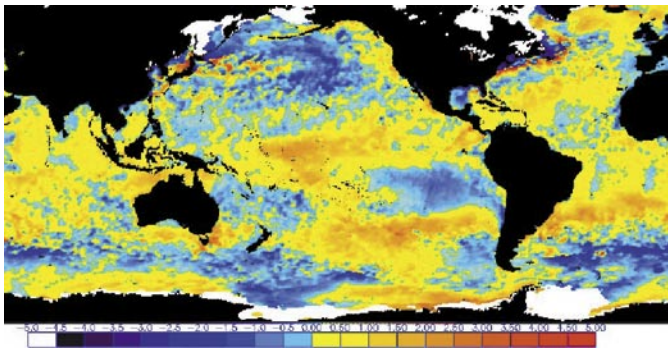
Volcano Eruption and El Nino

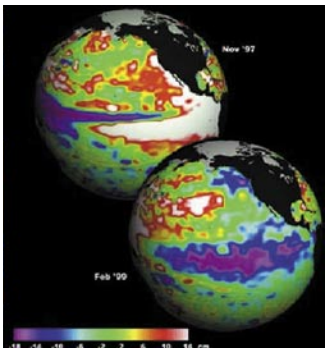
Among the phenomenon related to global climate change are volcano eruptions and El Nino. Upper Atmosphere Research Satellite (UARS) has been used for detecting volcano eruptions, for example, Mount Pinatubo in Philippines which ejected a cloud of sulphur dioxide into the atmosphere. In three months, these clouds completely encircled the Earth, as shown from space (below, right) and within a year, SO_2 particles in the atmosphere were providing glorious sunsets (below, left) all over the globe.



El Nino occurs with some regularity (although not completely predictable) around Christmas time. This natural phenomenon can be monitored by using National Oceanic and Atmospheric Administration (NOAA) satellite (right). El Nino causes a pool of warm water from the western Pacific Ocean to move eastward to the western coast of South America. In the process, weather patterns around the world change, often causing much damage to human populations including South American fish populations. In non-El Nino years, fish are abundant in this region, because of the cold, nutrient-filled waters. When El Nino occurs, the cold water flows deep into the Pacific, and fish populations decline dramatically, affecting the livelihood of humans who depend on fishing as an economic activity.





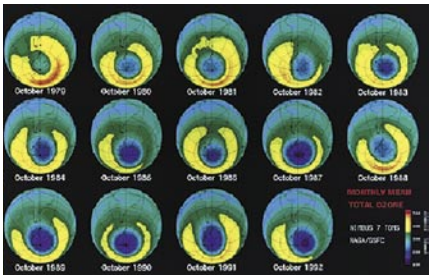


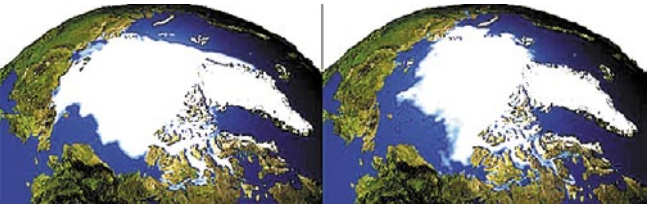
Increase in Earth's Temperature

Space sensors, particularly meteorological and oceanographic measurements, have been used to monitor the global mean annual temperature. The Seasat Radar Scatterometer shows prevailing wind patterns over the oceans at super continental scales. The left image (above) depicts the mean day, night, and day-night temperatures of the Earth's land and sea surfaces, averaged for January of 1979, from Nimbus 6's High-resolution Infra-red Sensor (HIRS) 3.4 and 4.0 µm channels integrated with MSU microwave and infrared data. The NASA Goddard Institute for Space Science (GISS), used Aqua satellite with Advanced Microwave Scanning Radiometer-EOS (AMSR-E) instruments to provide global data covering very short time spans. The image on the right (above) is a map of worldwide surface temperatures on 27 August 2003. A NASA study concluded that the global atmosphere has been slowly warming, cumulatively totalling about 0.5˚C with year 2005 being the warmest year on record.

Ozone Layer Depletion

Ozone in the stratosphere absorbs incoming solar ultraviolet radiation (UVR) that is dangerous to living systems. This UVR causes damage to the genetic material in living systems. Ozone prevents the UVR from reaching the Earth's surface, and so protects us from its harmful effects. Spacecraft sensors have observed ozone depletion during the Antarctic winter. Space sensors have observed similar (although smaller) depletions in the Arctic. These depletions have come to be known as 'ozone holes'. The image on the Antarctic variations in ozone level are depicted in 3-D by 'contouring' the different values. It is obvious that the size and extent of the 'hole' varies with time in this series of October Antarctic ozone maps taken between the years 1979 and 1992 (below).

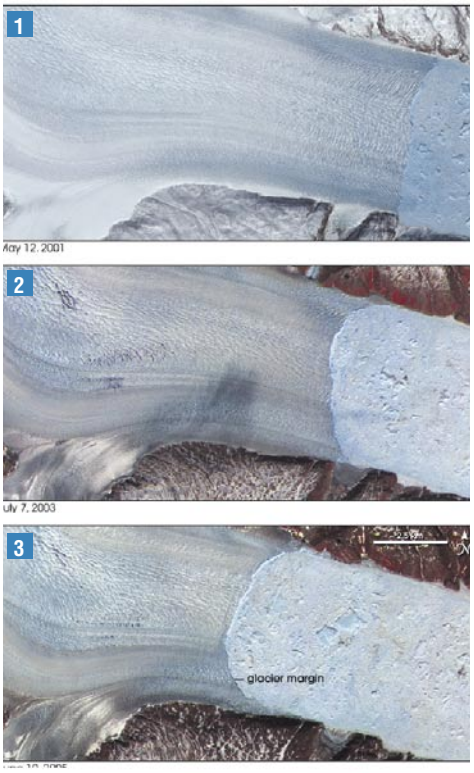




Glacier Melting and Sea Level Rise

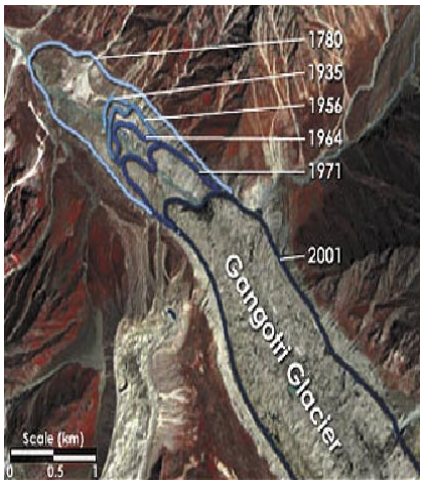
Satellite images from Special Sensor Microwave Imagery(SSMI) taken in 1979 (above, left) and again in 2003 (above, right) shows the Arctic Ocean appearing to open up, off eastern Siberia and northern Alaska.

The satellite images (below) from the Advanced Space borne Thermal Emission and Reflection Radiometer (ASTER) satellite shows the Helheim glacier in June 2005 (1), July 2003 (2) and May 2001 (3). The glacier occupies the left part of the images, while large and small icebergs pack the narrow fjord on the right part of the images. Bare ground appears brown or tan, while vegetation appears in shades of red.

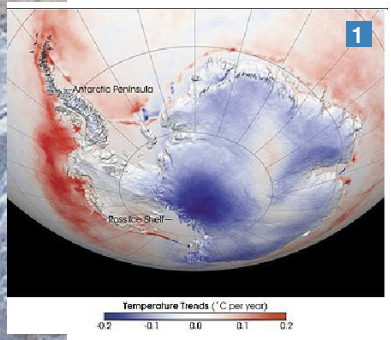


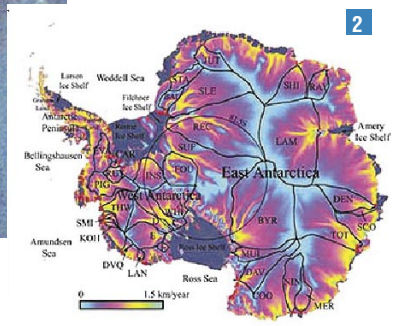
Satellite observations of eastern Greenland's Helheim Glacier show that the position of the iceberg's calving front, or margin, has undergone rapid and dramatic change since 2001, and glacier flows to the sea has sped up as well. From the 1970s until about 2001, the position of the glaciers margin changed a little. But between 2001 and 2005, the margin retreated landward about 7.5 kilometres (4.7 miles), and its speed increased from 8 to 11 kilometres per year. Between 2001 and 2003, the glacier also thinned by up to 40 metres (about 131 feet). Scientists believe that the retreat of the ice margin plays a big role in glacier acceleration. Overall, the margins of the Greenland Ice Sheet have been thinning by tens of metres over the last decade.

Glaciers in Asia also show notable retreats, as shown for the Gangotri glacier (below).



In the Antarctic Peninsula, a cumulative temperature rise of between 2 to 3°C (3.6 to 5.4°F) has occurred in recent years. The map, made from National Oceanic and Atmospheric Administration Advanced Very-High-Resolution Radiometer (NOAA AVHRR) data, shows that the exterior parts of the Antarctic and surrounding waters have warmed in the last 22 years (1, below). In the last few years, parts of the fringing Antarctic ice shelves have broken loose as massive icebergs floating northward. Use of laser altimetry and interferometric measurements of data obtained by InSAR (Interferometric SAR) are showing up as annual velocities of ice movement both within the continent and along its edges (2, below).





Recently in September 2008, the North Pole became an island for the first time in human history. This was revealed by satellite images from NASA, showing that both the northwest and northeast passages are now open due to the melting ice. These passages have not been open, simultaneously, since the beginning of the last Ice Age, 125,000 years ago. Mark Serreze, a specialist at the US National Snow and Ice Data Center, said the images suggest that the Arctic might have entered a 'death spiral' caused by climate change. Shipping companies are already planning to use the new routes.

Satellite imagery can also be used to measure actual sea level rise in a decade as well as draw up a predictive map if the sea level were to rise just 5 metres (about 16 feet).

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Climate Change Modelling: The Malaysian Experience

As outlined in the last paper, under the requirements of UNFCCC for NC2, the seven sub-sectors where the likely impacts of climate change are being studied are agriculture, forestry, biodiversity, water resources, coastal and marine resources, public health and energy. The task of the National Hydraulic Research Institute of Malaysia (NAHRIM) is to undertake an assessment of the impact of future climate change on the hydrologic regime and water resources of Peninsular Malaysia. To undertake this task, NAHRIM has conducted a study to downscale the climate change simulations of a coarse scale Canadian General Climate Model (CGCM1) to the region of Peninsular Malaysia at fine grid resolution using the Regional Hydro-climate Model of Peninsular Malaysia The results of the downscaling for future rainfall, river flow and air temperature are presented in this paper.

Approach and Methodology

Regional coupled hydrologic-atmospheric model of Peninsular Malaysia (RegHCM-PM) comprises a mesoscale atmospheric model component and a regional land hydrology model component that is similar to the Integrated Regional Scale Hydrologic-Atmospheric Model (IRSHAM)(CHRL, 2003; 2006) for Japan. The land surface hydrology component of IRSHAM is physically-based, describes evapotranspiration, sensible heat flux, short wave/long wave radiation, soil water flow and direct runoff in terms of area averaged conservation equations.

The assessment of the impact of climate change over Peninsular Malaysia was performed by a comparison of historical simulations of rainfall, air temperature, evapotranspiration, soil water storage, and river flow by the CGCM1 /RegHCM-PM combined models during the 1989-1993 periods against their future counterparts, simulated by the same models during the 2025-2034 and 2041-2050 twenty-year future period. However in this article, the assessment is only presented for surface air temperature, rainfall and river flow.

Assessment of Climate Change Impacts on Hydrologic Regime

Rainfall

Figure 1 shows the map of the subregions of Penisular Malaysia where the assessment was done. The long-term trend of annual rainfall is not pronounced because the interannual variability in rainfall is quite large. Table 1 and Figure 2 show simulated monthly rainfall, in which there will be a substantial increase in mean monthly rainfall over the North East Coastal region, and over Kelantan while there will be a decrease in mean monthly rainfall over Selangor and Johor. Generally, it may be inferred from this table that since higher maximum and lower minimum rainfall are observed in the future in many subregions, more extreme hydrological conditions may be expected. Maximum monthly precipitation also increases up to 51% over Pahang, Kelantan and Terengganu. Minimum monthly precipitation also decreases from 32% to 61% for all over Peninsular Malaysia.

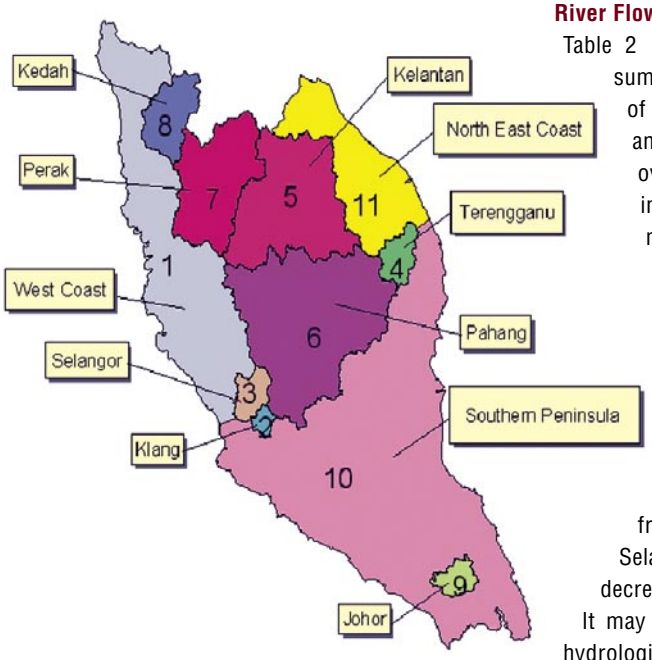

Figure 1: Subregions of Peninsular Malaysia where the impact of climate change was assessed.

River Flow

Table 2 and Figure 3 provide a summary of the assessment of the simulated historical and future flow conditions over Peninsular Malaysia in terms of maximum, mean, and minimum monthly flows at the selected river stations. This table shows that the mean monthly flows stay about the same in most watersheds except in Kelantan and Pahang where it increases from 11% to 47% and Selangor and Johor where it decreases from 31% to 93%. It may be also inferred that the hydrological extremes will be magnified significantly in Kelantan,

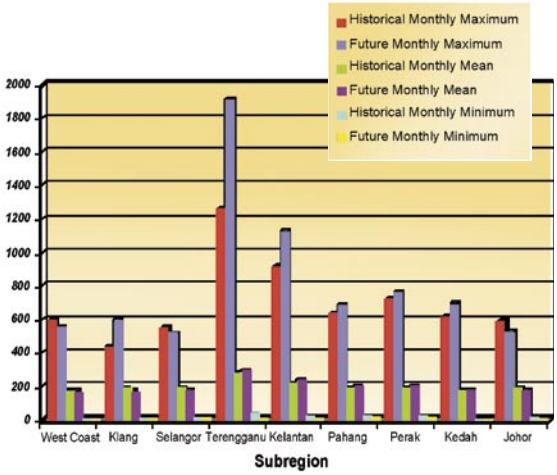

Figure 2: Simulated monthly rainfall at subregions of Peninsular Malaysia during simulated historical and future periods.

Table 1: Summary of simulated monthly rainfall during the historical and future periods at the selected watersheds of Peninsular Malaysia.

Subregion Name		West Coast	Klang	Selangor	Terengganu	Kelantan	Pahang	Perak	Kedah	Johor
Maximum Monthly Precip (mm)	Historical	600.0	436.2	564.1	1271.2	929.7	633.6	722.9	626.7	591.7
	Future	560.3	601.3	525.7	1913.9	1128.5	684.6	767.8	705.3	538.2
	Diff.	-39.7	165.1	-38.4	+642.7	+198.8	+51.0	+44.9	+78.3	-53.5
	(%)	-6.6	+37.8	-6.8	+50.6	+21.4	+8.0	+6.21	+12.5	-9.0
Mean Monthly Precip (mm)	Historical	179.2	190.1	190.2	289.0	221.8	198.5	192.9	173.6	187.3
	Future	176.2	182.3	180.9	299.0	239.5	208.4	199.4	176.6	180.0
	Diff.	-3.0	-7.8	-9.3	+10.0	+17.7	+9.9	+6.5	+3.0	-7.3
	(%)	-1.7	-4.1	+4.9	+3.5	+7.9	+4.9	+3.4	+1.7	-3.9
Minimum Monthly Precip (mm)	Historical	12.4	12.8	12.2	33.6	15.4	24.5	9.0	2.1	13.3
	Future	7.9	5.9	8.3	14.0	10.9	16.6	4.1	1.1	5.2
	Diff.	-4.5	-6.9	-3.9	-19.6	-4.5	-7.9	-4.9	-1.0	-8.1
	(%)	-36.3	-53.9	-32	-58.3	-29.2	-32.2	-54.4	-50	-60.9

Table 2: Summary of simulated river flows during the historical and future periods at the selected watersheds of Peninsular Malaysia.

River		Klang	Selangor	Dungun	Kelantan	Pahang	Perak	Muda	Johor
Maximum Monthly Flows (cms)	Historical	31.2	107.9	398.4	1535.1	1697.4	523.7	307.4	82.7
	Future	45.8	108.5	569.5	1950.7	2176.6	578.2	340.0	94.0
	Diff.	+14.6	+0.6	+171.1	+415.6	+479.2	+54.5	+32.6	+11.3
	(%)	+46.8	+0.6	+42.9	+27.1	+28.2	+10.4	+10.6	+13.7
Mean Monthly Flows (cms)	Historical	14.4	40.7	93.4	535.9	669.6	286.4	105.6	32.7
	Future	13.3	37.5	98.3	601.7	718.1	299.7	104.0	31.8
	Diff.	-1.1	-3.2	+4.9	+65.8	+48.5	+13.3	-1.6	-0.9
	(%)	-7.6	-7.9	+5.2	+12.3	+7.2	+4.6	-1.5	-2.8
Minimum Monthly Flows (cms)	Historical	2.6	7.1	13.1	158.4	156.3	183.6	25.3	9.8
	Future	3.5	0.5	10.8	125.8	122.7	139.2	5.3	6.8
	Diff.	+0.9	-6.6	-2.3	-32.6	-33.6	-44.4	-20	-3
	(%)	+34.6	-93.0	-17.6	-20.6	-21.5	-24.2	-79.1	-30.6

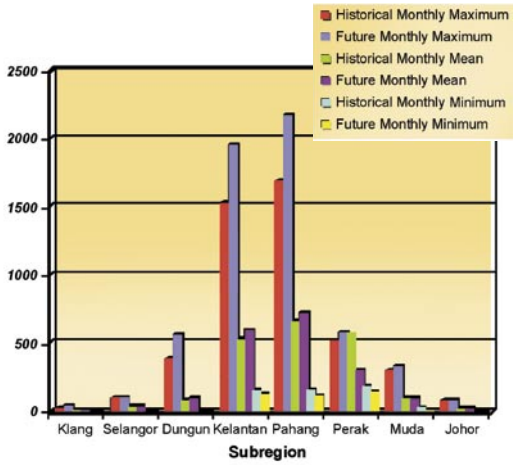

Figure 3: Simulated monthly river flows during the historical and future periods at the selected watersheds of Peninsular Malaysia.

Terengganu and Pahang watersheds. In the future, monthly flows will be lower and the maximum monthly flows will be significantly higher than their historical counterparts in these watersheds. This show an increase in inter-annual and intra-seasonal variability with increased hydrologic extremes (higher high flows, and lower low flows) are expected in Kelantan, Pahang, Terengganu and Kedah watersheds in the future.

Air Temperature

Table 3 and Figure 4 show the simulated annual mean air temperature at every subregion during the historical (1984-1993) and the future (2025-2034 and 2041-2050) periods. From the table it can be concluded that monthly mean temperature during the future period is higher than that during the historical period. Monthly mean temperature during the future period is higher than during the historical period up to 1.4 ˚C. Maximum monthly temperature also increases up to 2 ˚C.

Hydroclimate Database

The database which consists of the five modules of precipitation, evapotranspiration, soil water storage, surface temperature and stream flow can be accessed by logging into www.nahrim.gov.my and then registering.

Conclusion

The expected changes in the hydrologic regime, that is, extremes in the form of rainfall, streamflow and air temperature of Peninsular Malaysia would have impacts on the seven subsectors that need to be assessed in more detail. Specifically so in the public health sector where the changes in temperature and rainfall patterns could lead to prolonging of vector breeding season, breeding sites, boosting reproduction rates and the consequent spread of vector borne diseases. The future increase in drought frequency and intensity coupled with increases in air temperature would create conditions for forest fires in peat areas leading to air pollution and haze which would also impact on public health. Hence, the future hydroclimate projection as mentioned above would be useful to all stakeholders for detailed vulnerability assessment and the development of appropriate adaptation measures for the public health sector in particular and also for other vulnerable sectors in Malaysia.

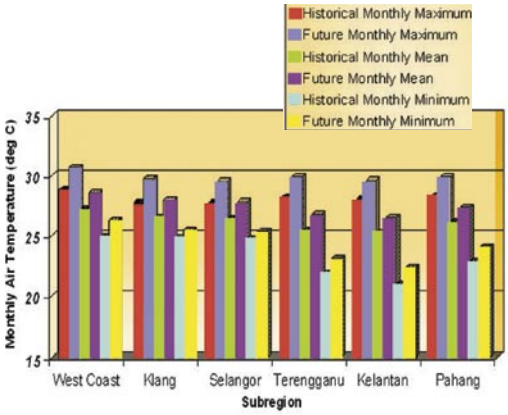

Figure 4: Simulated monthly air temperature during the historical and future periods at the subregion of Peninsular Malaysia.

Table 3: Summary of simulated air temperature during the historical and future periods at every subregion of Peninsular Malaysia.

Subregion Name		West Coast	Klang	Selangor	Terengganu	Kelantan	Pahang
Maximum Monthly Air Temp (˚ C)	Historical	28.9	27.7	27.7	28.2	28.0	28.3
	Future	30.7	29.7	29.5	29.9	29.6	29.9
	Increase	1.8	2.0	1.8	1.7	1.6	1.6
	% Increase	6.2%	7.2%	6.5%	6.0%	5.7%	5.7%
Mean Monthly Air Temp (˚ C)	Historical	27.3	26.5	26.4	25.5	25.3	26.1
	Future	28.6	27.9	27.8	26.8	26.5	27.4
	Increase	1.3	1.4	1.4	1.3	1.2	1.3
	% Increase	4.7%	5.3%	5.3%	5.1%	4.7%	5.0%
Minimum Monthly Air Temp (˚ C)	Historical	24.9	24.8	24.7	21.9	21.0	22.8
	Future	26.2	25.5	25.4	23.1	22.4	24.1
	Increase	1.3	0.7	0.7	1.2	1.4	1.3
	% Increase	5.2%	2.8%	2.8%	5.5%	6.7%	5.7%

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Intergovernmental Panel on Climate Change Assessment Report No. 3

Source
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Malaysia's Second National Communication to the UNFCCC (NC2) Project

A UNDP/GEF enabling activity executed by the Ministry of Natural Resources and Environment

The phenomena of climate change, the World Meteorological Organisation (WMO) and the UN Environment Programme (UNEP) established a body of scientific experts called the Intergovernmental Panel on Climate Change (IPCC) in 1988. Their first report effectively led to the establishment of the UN Framework Convention on Climate Change (UNFCCC) in 1992, which is the global pact to reduce dangerous anthropogenic impacts on the climate.

It soon became clear that a more concerted effort was required to address this issue. Hence in 1997, the Kyoto Protocol under the UNFCCC was formulated wherein developed nations were given emission reduction targets to result in an overall reduction of greenhouse gas (GHG) emissions of 5% below the 1990 levels. The Kyoto Protocol came into effect in 2005, once the requisite number of countries had become signatories. The targeted reduction is to be achieved in the First Commitment period (2008 – 2012).

In its most recent publication entitled the Fourth Assessment Report in 2007, the IPCC concluded that:

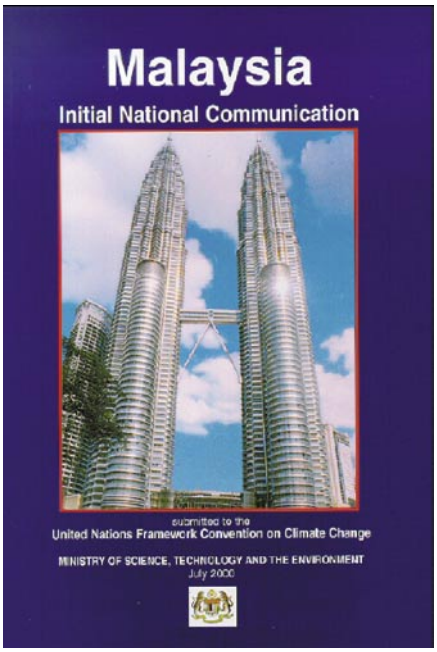
- "Warming of the climate system is unequivocal as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level."
- "Most of the observed increase in globally averaged temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic greenhouse gas concentrations." ('very likely' means "the assessed likelihood, using expert judgment, is over 90%")

Hence the global scientific consensus is that it is more than 90% certain that GHG emissions by human activities are raising global temperatures.

Presently, after last year's UNFCCC Conference of Party meeting in Bali, the world community is in the midst of negotiating a post-2012 agreement, anticipated to be recorded in Copenhagen in 2009.

Malaysia and Climate Change

Malaysia is a signatory to both the UNFCCC and the Kyoto Protocol and participates actively in the negotiations and implementation involving both of them. Malaysia, as a developing country, or a Non-Annex 1 Party, has different obligations from developed countries or Annex 1 Parties. This is due to the recognition given in the convention that while all nations must play their rightful roles in addressing global warming, developed nations are largely, though inadvertently, responsible for the phenomena we are facing today. The activities they undertook to become industrialised and developed resulted in much deforestation and pollution, the impacts of which the entire world is facing today. Hence, in applying the principle of "common but differentiated responsibilities", the convention text assigns different obligations to the different parties who fall into Annex 1 or Non-Annex 1 parties respectively.



Countries like Malaysia are required to prepare a document called the National Communications periodically which will report on the national GHG Inventory for a specified year as well as record activities undertaken to address the issue of climate change, be it in reducing GHG emissions, or more critically for developing countries, to adapt to inevitable changes.

Malaysia's first effort in meeting its convention obligations resulted in the report called the Initial National Communication (INC) that was submitted to the UNFCCC in 2000 (http://nc2.nre.gov.my/ , please see Publications/INC). An inventory for the year 1994 was prepared covering GHG emissions from the energy, industrial processes, land use and forestry, agriculture and waste sectors. The amount of carbon that was sequestered or absorbed by our forests was also estimated. The data showed that we had emitted 144,314 Gg CO_2 eq[1] and absorbed 68,717 Gg CO_2 eq for 1994.

Some projections of emissions were also made into the future and recommendations as to how to reduce carbon emissions were proposed. These included applying renewable energy measures such as photovoltaic cells for electricity generation and also exploring ways to become more energy efficient.

Another important part of the report was on assessing the vulnerabilities of various sectors to the impacts of climate change (Table 1 summarises the findings).

The NC2 Project

Presently, Malaysia is undertaking the second National Communication to the UNFCCC. The project entitled the Second National Communication/NC2 project is a national level project which has received funding support from UNDP/GEF[2] and is spearheaded by CEMD, NRE[3]. Preparation of this report has the added effect of enabling Malaysia to undertake future climate related activities and provide relevant information towards the national planning process on climate change by enhancing existing scientific and technical knowledge and capacity.

The NC2 will report on the national GHG inventory for the year 2000 considering emissions and absorptions for the following sectors: Energy and Transportation (mainly emissions from fossil fuel consumption); Industrial Processes (emissions from mineral, chemical and metal productions); Land Use, Land Use Change and Forestry (emissions from forest conversion and some soil emissions and absorptions from forest management and conversion of abandoned land); Agriculture (emissions

Table 1: Summary of impacts and proposed measures on identified sectors.

Sectors	Impacts	Proposed Measures
Agriculture	Food security, drop in yield, disease	Cultivate more resistant plant varieties
Water Resources	Annual flood damage of RM100m	Increase reservoir capacity, demand side management
Coastal Resources	Tidal inundation, shoreline erosion, increased wave action, saline intrusion, fisheries losses	Integrated coastal zone management system
Public Health	Dengue, malaria, respiratory ailments	Strengthen emergency preparedness and disaster management plan
Energy Transport	Higher demand, higher production cost Storms on sea transport Sea level rise on ports	More weather resistant construction of offshore sites
Forestry	Release of stored carbon	Strengthen and integrate conservation of protected areas, national seed bank

from lifestock management, rice cultivation, field burnings and fertiliser applications); and Waste (emissions from solid waste, domestic and commercial waste water treatment and industrial wastewater treatment).

The main GHGs that will be inventorised are carbon dioxide, methane and nitrous oxide. Preliminary figures have shown increased emissions from all sectors between the years 1994 and 2000. At the same time, we have gained a much better understanding of the carbon absorption capacity of our forests. A time series is also expected to be completed that can be used for trend analysis in our emission patterns.

The NC2 will also review plans to address climate change and improve on these plans based on more recent information. This will be approached from two perspectives: measures to reduce GHG emissions from key sectors, especially the energy sector, and measures to enhance carbon absorption by our forests; and evaluating the vulnerabilities and measures to adapt to climate change, especially in seven key sectors.

Climate projections will include projections from a downscaled Global Climate Model to 9 km grid for Peninsular Malaysia that was developed by NAHRIM[4] to study the impact of climate change on our hydrologic regime and water resources. NAHRIM has also an online database that provides future projections of temperature, rainfall, river flow that can be accessed upon registration http://www.nahrim.gov.my/english/index.html. Work is presently underway for a model for East Malaysia. In addition, the MMD[5] that is part of the Climate Projections team also collects important data for climate projections and is working on climate projections using another model.

Another important aspect that will be considered in the NC2 is the socio-economic impact of climate change on the seven sectors to provide a more holistic and comprehensive analysis. This analysis is lead by UKM's LESTARI with participation from experts from other universities.

Health impacts; coastal and marine vulnerabilities; biodiversity impacts; water, food and energy securities will also be considered. Results from ongoing studies such as the impact of climate change on vector borne diseases by IMR[6] and the National Coastal Vulnerability Study by DID[7] will provide important local data and analysis in advancing our understanding of impacts from climate change.

In terms of ecosystems like forests that are vulnerable to climate change and at the same time are climate change mitigators as they are nature's way of absorbing atmospheric carbon, much cutting edge research is being undertaken, especially by FRIM[8] to better understand tropical forest services towards climate regulation, and their vulnerabilities.

Analysis and projection studies by PTM[9] on energy consumption patterns and effectiveness of measures in reducing fossil fuel dependence are expected to provide strategic guidance to our policy makers.

CDM[10] activities in the country will also provide important data and information concerning emission reduction activities. The three CDM technical secretariats, PTM (energy), MARDI[11] (agriculture) and FRIM (forestry) are also members of the NC2 project.

The NC2 will thus report on all these and other important activities undertaken by institutions such as MARDI on crop modelling and food security, DOE[12] on air pollution, JPSPN[13] on solid waste management, Forestry Departments on the implementation of our Sustainable Forestry Management (SFM) and Reduced Impact Logging (RIL) programmes, and others that enhance our knowledge of the sources of emissions, and the sensitivities of different sectors to climate changes and variabilities to enable formulation of meaningful strategies to address this issue.

Project Organisation

The Project Steering Committee (PSC) comprises 22 members from different ministries, NGOs[14] such as CETDEM[15] and MNS[16], think tanks such as ISIS[17], the private sector, FMM[18] and an international organisation, the UNDP. It provides important top management guidance and cross sectoral inputs towards the project. It ultimately presents the final NC2 report to the more permanent body, the NSCCC.

The Project Management Group (PMG) is headed by the National Project Director (NPD) who is the Under Secretary of CEMD, NRE, and guides the management of the project with UNDP. The project is managed by the NC2 secretariat, comprising the National Project Coordinator (NPC) and Assistant Project Coordinator (APC).

Footnotes

1. GgCO2 eq = Gigagrammes of carbon dioxide equivalent. This is the unit to measure emissions and it converts other GHGs into carbon dioxide values based on their global warming potential.
2. United Nations Development Programme/ Global Environment Facility
3. Conservation and Environment Management Division, Ministry of Natural Resources and Environment
4. National Hydrological Research Institute Malaysia
5. Malaysian Meteorological Department
6. Institute of Medical Research
7. Department of Irrigation and Drainage
8. Forest Research Institute of Malaysia
9. Pusat Tenaga Malaysia
10. CDM or the Clean Development Mechanism is the only mechanism under the Kyoto Protocol that developing countries like Malaysia can participate in. CDM enables tradable certified carbon credits to be issued for activities that result in a reduction of carbon emissions.
11. Malaysian Agriculture Research and Development Institute
12. Department of Environment
13. Jabatan Pengurusan Sisa Pepejal Negara
14. Non Governmental Organisations
15. Centre for Environment, Technology and Development, Malaysia
16. Malaysian Nature Society
17. Institute of Strategic and International Studies
18. Federation of Malaysian Manufacturers

Queries/Information

Further details regarding the NC2 project can be obtained from **http://nc2.nre.gov.my/** or please contact Lavanya Rama Iyer, NC2 National Project Coordinator, at **iyerlavanya@nre.gov.my** or **(+603) 8886 1689.**

Event Highlights

Department of Environment, Malaysia

June 2008

Environmental Crisis and Disaster Management Seminar

The Department of Environment successfully organised a one-day seminar on 'Environmental Crisis and Disaster Management' at its headquarters in Putrajaya on June 19, 2008. This primary attempt by the DOE, however, received awe-inspiring support from the private and public sector counterparts with well over a hundred and forty participants. Mr. Hashim Bin Daud, Director of Water and Marine Division, delivered the opening remarks on behalf of the Director General of Environment. With an excellent line up of experienced speakers, the seminar introduced concepts and principles in crisis and disaster management and outlined the evolution of crisis and disaster management in Malaysia. Issues of work safety at site and case studies pertaining to site specific hazard management experiences were stimulating. Nevertheless, the much anticipated and contentious session on media handling during a crisis was distinctly a crowd-puller, matching the expectations of the participants.

July 2008

18th Inter-University Environmental Debate

Organised by Department of Environment (DOE) in collaboration with the Malaysian Universities Debate Council (MADUM), Dewan Bahasa dan Pustaka (DBP) and Ministry of Higher Education, the 18th Inter University Environmental Debate saw participation from 24 teams from 24 institutions of higher learning in Malaysia. University Malaysia Sabah (UMS) in Kota Kinabalu, Sabah hosted the event from 26 - 29 July 2008. The two teams that made it to the finals of the 2008 Debate held at Dewan Resital of University Malaysia Sabah were Universiti Islam Antarabangsa (UIAM) and Universiti Institut Teknologi Malaysia (UiTM). UiTM emerged the overall winner of the 2008 Debate, receiving the Minister of Natural Resources and Environment Challenge Trophy, a cash prize of RM 8,000.00 and a certificate of participation. Farhan Noor Diyana of UIAM emerged as the Best Debater and received the Director General of Environment Trophy, together with a cash prize of RM1,500.00. YB Senator Dato' Maznah Mazlan, the Deputy Minister of the Ministry of Natural Resources and Environment gave away the prizes. The Department hopes that participation from universities and institutions will increase in the yearly event.

August 2008

DOE Environmental Awareness Camp (KeKAS)

Organised by DOE in collaboration with the Ministry of Education, the DOE Environmental Awareness Camp was held at the Forest Research Institute Malaysia (FRIM) Kepong, Selangor from 19-21 August 2008. This is the first time that 16 DOE officers from East and West Malaysia and 30 students from Sekolah Menengah Precinct 9(1) Putrajaya who participated in the camp. The activities comprised of environmental games and water, forest and soil activities.

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