A Climate for Change

Climate change in the Asia Pacific

regions –some thoughts on consequences and actions

- an Australian perspective

Dr Geoff Rigby
Newcastle, New South Wales, Australia
rigby@mail.com

This paper has been prepared to provide a summary and background material for delegates attending the Christian Conference of Asia in Seoul from 13-18 May 2008. Material has been drawn from a variety of sources as well as the author's personal background and experiences. Every attempt has been made, where appropriate, to acknowledge the source of the information used.

May 2008
rigby@mail.com

Summary …… 3

1. Introduction ……. 4

2. Global climate change, greenhouse gases and global warming ……. 4

3. Consequences of global warming ……. 5

3.1 Increases in ocean temperatures, level and acidity…… 5
3.2 Infectious disease and heat-related mortality …… 7
3.3 Water resources …… 8
3.4 Agriculture and forestry …….. 8
3.5 Biodiversity and ecosystems …… 9
3.6 Economic impacts ……. 10
3.7 Overall regional impact assessment summary …….. 10

4. Mitigation of climate change …… 11

5. Adaption to climate change ……. 14

6. What role can the church play? …… 17

7. References…… 21

Summary

Changing climate has been a part of our natural environment for thousands of years. However increasing global temperatures attributed essentially to anthropogenic (human induced) greenhouse gas emissions has focused widespread media and general community concern about many of the future consequences.

A number of international studies predict that a potentially dangerous overall temperature increase of approximately $2^{O}C$ above pre-industrial temperatures could occur by around 2050 and that further increases beyond this level will continue unless greenhouse gas emissions are reduced. The Asia/Pacific region is host to approximately 60% of the world's population and contributes around 25% of the global domestic product.

Residents of the regions face a number of serious consequences arising from the predicted global warming including; increased sea levels, changed extreme weather patterns, acidification of the ocean, increased exposure to water-borne diseases and the quality of air, pressures on food and water security, productivity of agricultural cops, livestock and commercial forestry, effects on natural ecosystems and ecology and overall economic impacts.

The Asia/Pacific region contributes over 35% of the world's global greenhouse gas emissions, however between nation there are major differences in emissions. Many countries in the region contribute very little by way of emissions but nevertheless will be affected by the long term consequences. China is the world's largest emitter of greenhouse gases and together with India are responsible for approximately 25% of total emissions. Australia represents around 1% of emissions. Realistic policies and an understanding of responsibilities as well as coordination necessary between the large emitting nations and those who may suffer most from the resulting effects of climate change will be important as future actions are put in place in addressing the many issues involved.

Since a large proportion of greenhouse gases are produced from power generation, mitigation strategies to reduce these will need to focus heavily on improving efficiencies, using new technologies and further use of renewable options. Current programs in Australia and China represent a start in this direction. Introduction of some of these technologies, coupled with carbon related taxes will inevitably result in increased energy costs and future strategies will need to address the issue of social justice and economic assistance to those who are unable to bear these increased costs.

For many of the Asia/Pacific countries, the development and implantation of strategies to adapt to climate change consequences will have a higher priority than efforts seeking to reduce emissions. A variety of options have been suggested, however more extensive action will need to be taken to reduce the vulnerability of some areas.

If we are to take our stewardship of the earth seriously, the church has a very good reason and a wonderful opportunity to demonstrate our commitment to our communities and to those responsible for developing and implementing the broader policies that will ultimately address the consequences of climate change.

The challenge of a greater awareness, acceptance of a responsibility and putting actions in place at a personal and corporate level to minimise the effects of climate change and to address the many consequences is before us all. A number of examples of some actions are included for discussion.

1. Introduction

Changing climate has been a part of our natural environment for thousands of years. However recent political priorities and general concern about the so called ***Climate Change*** phenomenon associated with global warming attributed to increasing global temperatures from anthropogenic (human induced) greenhouse gas emissions has focused widespread media and general community concern.

Whilst a variety of potential actions are being pursued to reduce increasing greenhouse gas emissions in the long term (and hopefully reduce the rate of temperature increase), a number of serious consequences resulting from current and predicted temperature increases will have a significant impact on the lives of people in the Asia/Pacific region in the short term.

A number of recent excellent reports by CSIRO, the Intergovernmental Panel on Climate Change (ICCP), the Climate Change Roundtable, the Working Group on Climate Change and Development and others have provided detailed information about the scientific basis for global climate change together with observations on potential consequences and suggestions for actions to address some of these issues [1-6].

This paper seeks to provide a summary of some of the key factors involved and some suggestions related to the development and implementation of strategies to address these issues.

2. Global climate change-greenhouse gases and global warming

Although some scepticism exists about the role that human activities have played in affecting the climate system, scientific evidence strongly supports the fact that increases in global population and worldwide economy coupled with our historical dependence on fossil fuels as a primary source of fuel and energy has resulted in a significant change in the composition of gases in our earth's atmosphere [1]. These gases, especially the so called 'greenhouse gases', play an important role in providing a balance between the absorption and reflection of energy from the sun and hence the temperature at the earth's surface.

Water vapour is the primary greenhouse gas (GHG), however other gases including carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) are significant. Most of the sun's energy passing through the atmosphere is radiated back into space, however greenhouse gases trap some of the heat which is responsible for warming the earth to an approximate average annual temperature of around $14^{O}C$.

This natural greenhouse effect has been affected over the past centuries by human activities involving land clearing, combustion of fossil fuels, coal mining and farming, leading to the release of vastly increased amounts of greenhouse gases and increases in atmospheric concentrations that have acted to magnify the natural greenhouse gas effect.

Carbon dioxide levels have increased by approximately 36% relative to their concentrations prior to the industrial revolution. The average current atmospheric CO_2 concentration is approximately 384 parts per million (ppm) [8] and is considered to be higher than at any point over at least the past 650,000 years [9]. Nitrous oxide and methane concentrations have increased by 17% and 151%, respectively [10].

These increasing greenhouse gas concentrations have resulted in warming of the planet leading to an increase in the global average surface temperatures of approximately $0.8^{O}C$ since the mid 19th Century [1,11]. Analysis of trends by the ICCP has indicated that the 100 year linear trend in temperature (1906-2005) of $0.74^{O}C$ increased from the 100 year linear trend of $0.6^{O}C$ from 1901 to 2000. Increases in ocean temperatures have also occurred. The most recent report of the Intergovernmental Panel on Climate Change[1] has concluded that a significant part of this global warming is attributed to human activities.

3. Consequences of global warming

The increase in global temperatures and other associated effects resulting from accumulated greenhouse gases in the atmosphere has already resulted in a number of changes not previously experienced. These accumulated levels of gases, together with worldwide increases resulting from expanding use of fossil fuel in the next decades will mean that many of these changes will continue (and potentially become more significant) until mitigation actions begin to take effect.

For the next two decades a warming of about $0.2^{O}C$ per decade for a range of possible emission scenarios has been predicted and even if the concentration of all greenhouse gases and aerosols had been kept constant at year 2000 levels, a further warming of about $0.1^{O}C$ per decade would be expected [1].

Some of the main consequences that will have to be combated are briefly reviewed below. It should be recognised that many of the predictions concerning the key parameters that may ultimately affect our living patterns are based on a variety of different models that use various assumptions about emissions, ice melting, temperature increases and other factors. Consequently predicted outcomes will project various results, generally involving a range of expectations. The following comments are essentially based on overall expected predictions to give a general feel for what might be expected and should be considered in this light. The various IPPC reports provide specific details of these assumptions and variations [1-4].

3.1 Increases in ocean temperatures, levels and acidity

Increases in land and lower atmosphere temperatures will result in higher sea temperatures as heat is transferred to the sea resulting in thermal expansion of the sea ultimately resulting in increases in sea levels around the world (Figure 1). In addition water from land based ice such as glaciers and ice sheets may flow into the ocean leading to further increases in levels. It is noted that melting of floating ice in the ocean will not generally result in an increase in level since it only replaces the volume of water that it originally displaced [12].

In considering the most significant contributor to increasing sea levels, it is noted that if non polar glaciers such as those in New Zealand and Norway melted they would release water into the sea and contribute to a sea-level rise. Glaciers are sensitive to climate change and could melt rapidly. Losses of the ice sheet in Greenland are balanced by ice formed from snowfall. Predictions suggest that increased melting from higher temperatures could exceed ice formation from any increases in precipitation.

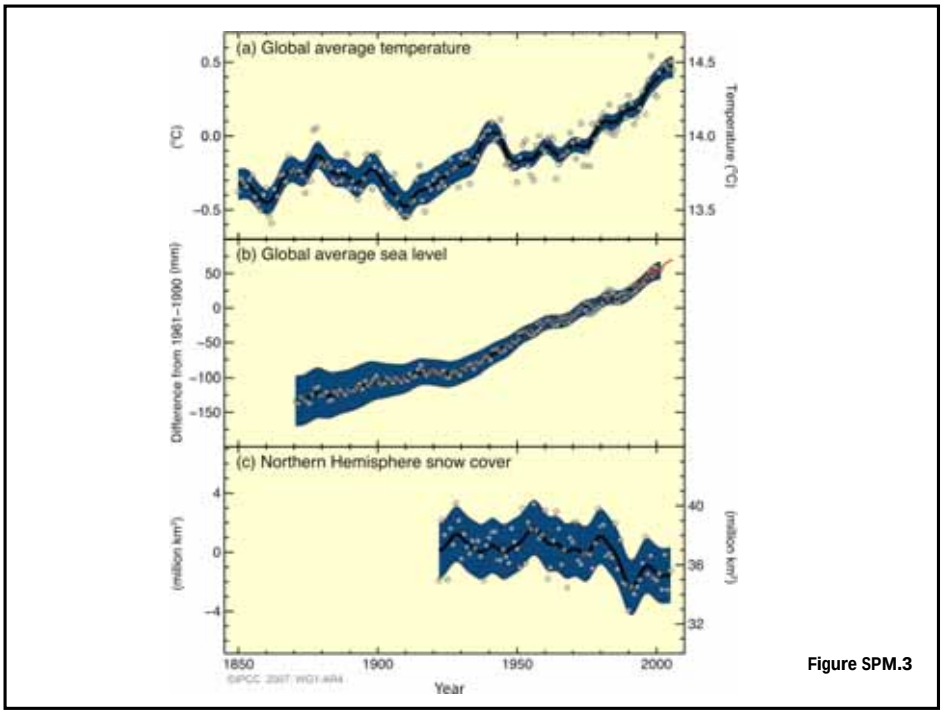

Figure 1 Observed changes in global average surface temperature, sea level and Northern Hemisphere snow cover for March-April [(1)].

The 2.5 km thick ice sheet covering Antarctica is equivalent to 30 million cubic metres of ice and if all of this were to melt it would result in an increase in sea level of around 60m. Temperatures in the Antarctic are so cold that even with a few degrees temperature increase, the temperatures would still remain below the melting point of ice and in fact it is expected that a small increase in temperature could result in more snow that would increase the amount of Antarctic ice [(12)].

The IPPC have predicted that thermal expansion of ocean water from increased temperatures is likely to be the dominant component of increasing sea levels.

Global average sea level since 1961 has risen by an average rate of 1.8 mm/yr and since 1993 at 3.1 mm/yr [(1)] allowing for contributions from thermal expansion, melting glaciers and ice caps, and polar ice sheets. It is not clear if this increase in the latter years is representative of longer term trends.

There are many uncertainties concerning the factors that will drive future changes in sea levels and hence long term predictions are regarded as being somewhat speculative. However it is expected that by 2100, sea levels could rise in many places by about 50cm.

About half of the carbon dioxide produced by burning fossil fuels is absorbed by the oceans, equivalent to a 30% increase in the concentrations of hydrogen ions [(13)] (indicative of the pH, a measure of the acidity), most of it remaining close to the surface. After being absorbed and mixed with sea water it forms carbonic acid which effectively lowers the prevailing pH [(14)].

Absorption of carbon dioxide from the atmosphere since 1750 has resulted in the ocean becoming more acid with an average decrease in pH of 0.1 units (Figure 2). The pH of the surface water around Antarctica is 0.1 units lower than it was before the industrial era and at

the current rate will be 0.3 lower by 2100, the lowest it has been in 300 million years [15].

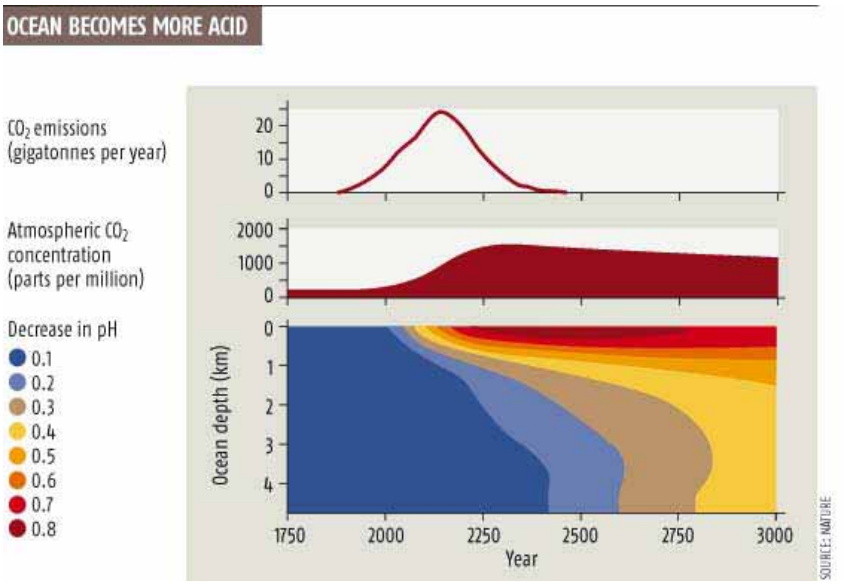

Figure 2 Increase in ocean acidification resulting from increasing absorption of carbon dioxide in the atmosphere [14] .

Whilst only limited research has been done to assess the effect of this acidification on marine life, coral and other carbonate-shelled sea life are finding it harder to form their calcium carbonate exoskeletons. It has been suggested that some ocean areas will be so corrosive by 2010 that the minute pteropod snails-so critical to the marine food chain-will be unable to form shells. Of particular concern are calcified organisms in deep, cold waters, where carbonate ions, affected by pressure and temperature, create a more acidic environment.

The effects of changes in climate and extreme weather events in the Asia/Pacific region are likely to create a number of challenges in the years ahead. As temperatures increase the likelihood of increased severity, frequency and duration of extreme heat events will increase. Whilst the effect of climate change on cyclone frequency and intensity reman unclear, model predictions project increases in cyclone intensity as temperatures increase [17].

3.2 Infectious disease and heat-related mortality

In the long term, in addition to water and food security, serious concerns have been raised about the changed distribution of infectious diseases such as malaria, dengue, and schistosomiasis that could increase the risk of water-borne disease and the quality of air.

Modelling studies suggest that most of the Asia/Pacific region (apart from central China) will continue to be a hot spot for malaria and dengue, with some isolated regions becoming more prone to epidemics and others less [5,18,19]. Changing patterns of rainfall may increase the risk of water contamination and water-borne illness [5,20].

Concerns about air quality deterioration as a result of increased temperatures leading to an increase in mortality suggest that these concerns could pose an increased health risk in the Asia/Pacific region and especially in some of the very large cities [21,22].

An assessment of the estimates for expected climate change across the Asia/Pacific region suggest that adverse health effects are likely at relatively low to modest warming of less than $2^{O}C$ [5]. For temperature increases of 2-4^{O}C, the impacts are suggested to be similar but more severe, with larger numbers of individuals exposed to or affected by infectious diseases as well as rising costs associated with their treatment.

It is important to recognise that like many of the possible effects of climate change, many of the potential health related effects are closely linked to socioeconomic conditions, and these considerations will have a bearing on the actual prevalence and incidence in the various populations, especially in relation to water quality.

3.3 Water resources

Access to reliable water resources is fundamental to human existence and to the local economy and challenges to effective management have been demonstrated in many parts of the world as a result of changing climatic conditions such as droughts, flooding, cyclones, tsunamis.

A number of countries in the Asia/Pacific region have already experienced water crises as a result of changing climatic events and population growth. Reduced river flows, land degradation, glacier retreat, floods, collection and water security in a number of countries and small-island states resulting from climate related events will impose significant pressure on the availability and management of water resources. Management of fresh water resources may be affected by increasing sea levels contributing to salt water intrusion and effects on local drainage in some areas.

Model studies assuming regional temperature increases of less than $2^{O}C$ suggest economic losses in South and Southeast Asia and for 2-4^{O}C, millions more are anticipated to be exposed to water stress throughout the Asia/Pacific region [5]. In some cases, as a result of increases in rainfall in some parts of Asia, the costs of water resources may be positive or negative in Asia but Oceania may experience economic losses.

3.4 Agriculture and forestry

The productivity of agricultural crops, livestock and commercial forestry are largely dependent on, and influenced by, seasonal patterns of temperature, rainfall and evaporation. Climate changes will have influences on these areas although net gains or losses will vary for different areas based on the changes in temperature, rainfall, effects on growing seasons. It has been suggested that improvements may result in some areas as a result of an enhanced CO_2 –fertilisation effect [23].

Climate change effects on agriculture can be varied. Water resources in some parts of the Asia/Pacific region are already stretched and so regional rainfall and evaporation effects will play a dominant role in prioritising the use of water for agriculture. In some areas, for example Bangladesh, Vietnam and small island states, the agricultural regions exist in low lying coastal margins or river deltas that are prone to flooding and hence sea level rise and

storm activity leading to inundation of this prime land will likely have an effect on consistency of supply and crop damage.

Various studies predict differing end results depending on the assumptions made. In China, for example, for a temperature increase of $2^{O}C$, some studies suggest improvements for rice, maize and wheat although one study predicts modest reductions in agricultural revenue. Crop yields in northeast China appear to be more vulnerable, with studies suggesting declines in yield from climate change, whilst the southeast appears to be a region of relatively low vulnerability and has potential to realise some benefits [24-26].

A review of all the national and regional studies indicates that it is difficult to gain a consistent picture of the overall likely effects of climate change on regional agriculture and forestry. Increased temperature, low lying and low rainfall areas appear to present the major problems, although it would seem that predicted increased rainfall throughout much of the region (at least in the short term) might help to reduce the problem. The effects of predicted reduced rainfall in Arid Asia, India and southeast Asia during the monsoon period require further examination.

3.5 Biodiversity and ecosystems

The implications of climate change related to natural ecosystems and biodiversity in the Asia/Pacific region present serious cause for concern. A high percentage of endemic species within the region, and including the high altitude areas of the Himalayas are dependent on these core habitats for their survival. Land use change and degradation, overexploitation of water resources and biodiversity, and contamination of inland and coastal waters and land already threatens many species.

Climate change projections suggest long term ecological damage [27]. Whilst some species have an inherent ability to cope with some climate variability and change, this can be relatively narrow for some species. In addition varying habitats resulting from changes in climatic conditions can upset the natural environment where some of the species exist.

Awareness of the mechanisms by which climate change may affect natural ecosystems and resources in the Asia /Pacific regions exists [28], however little quantitative information on potential impacts under specific climate change scenarios is available.

Assessments to date focusing on four key ecological areas; coral reef communities, mangrove wetlands, tropical and temperate forests and high altitude montane species are generally consistent in finding that climate change will pose adverse consequences to Asia/Pacific ecosystems [5].

Some specific concerns relate to the possible bleaching of coral reefs, reduced ability of some marine organisms to build their calcium carbonate skeletons (acidification), adverse effects on coastal mangroves, ability of montane species to migrate to higher cooler habitats, reduced Chinese boreal forests and grassland productivity in Arid and Semi-Arid Asia and dieback of tropical forests in Southeast Asia. Global studies also suggest the potential for significant extinction of plant and animal species in temperate and tropical forests such as those found in the Asia/Pacific region. Changes in some forest areas resulting from increased likelihood of forest fires and pest outbreaks are predicted to put greater stress on current populations.

3.6 Economic impacts

The limited number of studies that have attempted to quantify the potential overall economic impact of climate change on the Asia/Pacific area, generally indicate that net economic damage will occur [29]. Some examples that have been cited suggest the potential for annual GDP impacts of 2.4% on Sri Lanka for a temperature increase of less than $2^{O}C$. The Indian Ocean Tsunami in 2004 caused direct damage equivalent to 4.5% of Sri Lanka's GDP with an additional 7.5% of GDP required to refinance relief and reconstruction efforts. For a temperature increase of 2-$4^{O}C$, studies indicate economic losses in India, Bangladesh, Indonesia and Thailand, whereas one study predicts modest economic benefits to China. Given the possibility that temperature increases of 2-$3^{O}C$ could occur in these areas by 2070, planning for longer term economic realities would seem to require some priority in developing future strategies to manage the climate change impacts.

It is important to recognize that although economic impacts may be potentially large, the proportional regional economic effect needs to be considered in the context of likely continued economic development and growth and annual damaged from climate change effects may represent a declining proportion of the economy and have a minimal influence on regional prosperity.

3.7 Overall regional impact assessment summary

The CSIRO report [5] has reviewed 186 climate change impact assessment studies from the Asia/Pacific region (Figure 3). This review has allowed some general conclusions on the various consequences of climate change for the region to be presented. The following conclusions for the regional studies have been stated from this review.

It was noted that sixty-two percent of regional impact studies indicated adverse impacts, while only 14% indicated benefits. However 20-28% of estimates suggested the potential for either adverse or beneficial consequences from climate change, depending on assumptions and the variability of different sectors varied significantly.

One hundred percent of the regional estimates of the impacts to coastal communities indicate adverse physical and economic consequences, which grow progressively worse with higher magnitudes of sea-level rise. Results for the regions' ecosystems and other water resources are similarly pessimistic. The majority of studies also indicate the implications of climate change will be largely adverse for infectious disease and other health threats. Impacts to water resources are decisively negative, although at smaller geographic scales, individual nations or subregions may experience increased water availability due to higher rainfall amounts and subsequent runoff. Uncertainty in future regional rainfall regimes means that crop agriculture and commercial forestry at both regional and national scales could experience benefits or losses, although some nations appear to be clear losers, such as Bangladesh and the Pacific Islands. Finally, the majority of studies indicate climate change will damage Asia/Pacific economies, although the potential for economic benefits in some subregions does appear in the literature.

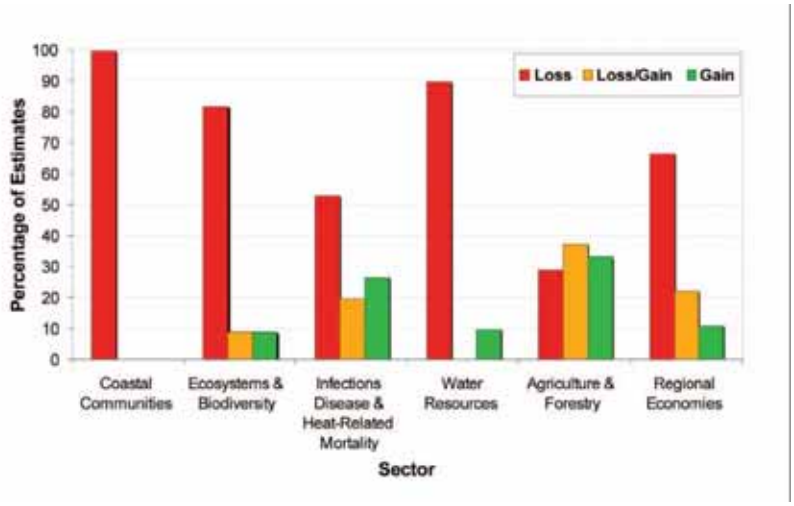

Figure 3 Indicators of the vulnerability of several Asia/Pacific sectors to climate change. Individual estimates (186 different studies) of climate change impacts are presented as a percentage of sectoral estimates that reflect losses from climate change, gains from climate change, or the potential for both gains and losses, depending on assumptions.

4. Mitigation of climate change

Greenhouse gases arising from human related activities are considered to be largely responsible for global warming. Gradual accumulation of these gases, especially over the past few decades as a result of increased industrialisation, population and expanding demands for transport fuels and energy, mean that global warming effects are not likely to diminish even if we are able to reduce these emissions. In order to minimise the long term global warming effects and associated consequences, it is crucial that we develop strategies to dramatically reduce the greenhouse gas emissions.

Annual anthropogenic global emissions have increased from 28.7 Gt (CO_2 equivalent) in 1970 to 49.0 Gt in 2004 (Figure 4) [(1)]. By far the largest proportion of GHG global emissions arise from CO_2 generated from fossil fuel, followed by that released from deforestation. Thirty nine percent of all emissions come from energy generation and transport. Clearly strategies to reduce the overall global emissions in the future (and hopefully limit the long term global warming effects) will need to concentrate on these areas.

In assessing the contributions that inhabitants of the Asia/Pacific make toward these global emission levels it is useful to look at the regional proportions relative to the overall global emissions (Table 1). Approximately 60% of the world's population resides within the Asia/Pacific region. The region accounts for over 35% of global greenhouse gas emissions,

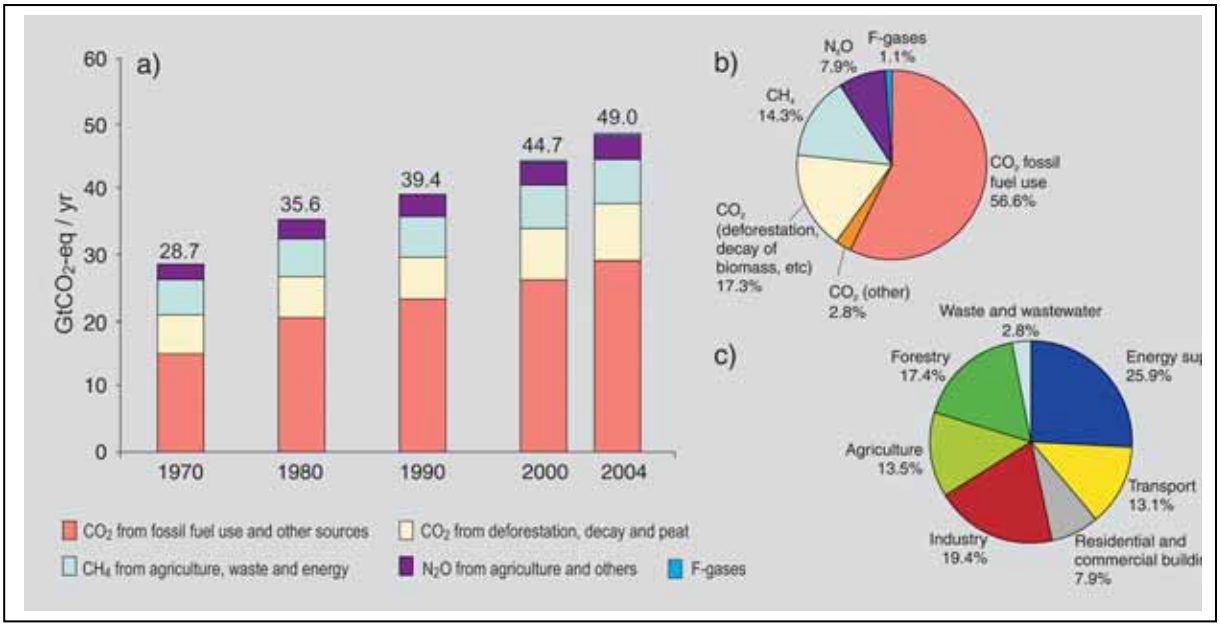

Figure 4 (a) Global annual emissions of anthropogenic GHGs from 1970 to 2004, (b) share of different anthropogenic GHGs in total emissions in 2004 in terms of carbon dioxide equivalents, (c) share if different sectors in total anthropogenic GHG emissions in 2004 in terms of carbon dioxide equivalents.

Nation	Pop. Growth Rate	GDP Per Capita [13]	Agriculture as a share of GDP	Pop. Access to Safe Water	Adult Literacy	CO2 Emissions p/ capita (tons)
Australia	1.1%	$23,249	3.5%	100%	-	17.3
Singapore	1.5%	$18,707	0.1%	100%	92.5%	13.1
Bangladesh	1.9%	$399	22.7%	75%	40.6%	0.2
China	0.6%	$799	15.4%	77%	82.8%	2.7
India	1.6%	$543	22.7%	86%	58.0%	1.0
Papua New Guinea	2.1%	$971	26.9%	29%	64.6%	0.5
Vanuatu	2.0%	$1,151	15.1%	60%	-	0.4
Vietnam	1.4%	$171	23.0%	73%	92.7%	0.7

Table 1 Vital statistics for selected Asian/Pacific nations [(5)].

However between nations there are major differences in emissions. Within the region, Australia's per capita contribution to GHG emissions is relatively high (8 times the average for China and 170 times that for Bangladesh). However total Australian emissions are about the same as Indonesia (20 million population compared to 200 million) and those of China and India are significantly higher. As the world's largest exporter of coal, Australia is expected to be exporting 270 million tonnes per year by 2010 (three times the amount of coal used in Australia).

When attempting to develop a balance between mitigating our regional emissions and adapting to the expected changes, it is important to put the regional situation into context. Historically, most counties in the region, apart from China and India have contributed relatively small proportions of GHGs to the world total (Table 2). The United States, European Union and the Russian federation have historically contributed approximately 65%, India and China account for around 9%, Australia 1% and the remaining nations very much less than 1%. Hence investing financially and by way of practical actions for these latter nations is likely to result in small direct benefits.

Top-10		*Bottom-10*	
Nation	**Responsibility (%)**	**Nation**	**Responsibility (%)**
United States	29.64	Seychelles	<0.01
European Union[n]	27.06	Bhutan	<0.01
Russian Federation	8.23	Solomon Islands	<0.01
China	7.24	Maldives	<0.01
Canada	2.14	Nauru	<0.01
India	2.07	Samoa	<0.01
Australia	1.05	Vanuatu	<0.01
Indonesia	0.48	Tonga	<0.01
Thailand	0.24	Kiribati	<0.01
Pakistan	0.18	Cook Islands	<0.01

Table 2 Historical selected country responsibility for CO_2 emissions (1850-2004) [5,28].

The relative responsibilities are vastly different for China and India and these nations are among the world's largest greenhouse gas emitters (approximately 25% of 2002 emissions) and with its rapidly developing economy and industrial expansion, China was reported to exceed the United States emissions in 2006 [31] by 8%, making it the world's largest emitter of GHGs. This rapid growth in GHGs has been driven by a massive growth in electricity generation, and in energy intensive industrial sectors, such as steel, cement, and non ferrous metals smelting (particularly aluminium).

These statistics highlight the need for realistic policies and an understanding of responsibilities as well as realisations of the coordination necessary between the large emitting nations and those who may suffer greatest from the resulting effects, in order to develop effective future strategies.

It is essential that meaningful steps be taken to mitigate global emissions both at a "corporate" and personal level. In the corporate sphere the introduction of carbon taxes in developed countries will be crucial in creating major reductions in GHG emissions and at the same time creating economic incentives to use a wider range of renewable energy technologies. A number of countries have experienced carbon taxes and realistic renewable energy targets for many years.

Since a large proportion of GHGs are generated from power generation, major reductions will ultimately need to come from this area. A number of options are presently available to reduce energy consumption and a variety of new technologies are being developed and demonstrated

to increase the efficiency of fossil fuel electricity generation and substantially reduce GHG emissions. Some of these options include;

- improved energy supply and distribution
- fuel switching from coal to gas
- combined heat and power to improve efficiency
- improved generation efficiency technology
- carbon capture and storage (CCS) for electricity generation
- reduced energy user consumption by smart management
- direct coal firing of diesel engines
- oxygen combustion to improve electricity efficiency
- solar thermal systems for electricity generation
- geothermal (hot rocks) electricity generation
- use of a nuclear power cycle
- other renewable energy generation options including photovoltaics, wind, wave.

In addition to power generation, significant opportunities exist in the transport, industrial and agricultural areas to reduce GHG emission associated with these sectors [(1)]. One key area of interest in the Asia/Pacific area is to improve forest management, reduce deforestation and increase forestation.

Australia has a major role to play in undertaking research and development in some of these areas and in demonstrating new technology and in sharing the development and expertise with large emitting countries in the Asia/Pacific areas. One example includes the current partnership that has been established between CSIRO and the Chinese Thermal Power Research Institute to demonstrate the use of CCS in association with electricity generation [(31)].

A variety of technical guidelines and aids are being developed to assist countries and organisations to develop and introduce various mitigation options with the overall aim of achieving at least a 60 percent cut to greenhouse gas emissions by 2050 [(32)].

In China it is interesting to note that for energy security, and to reduce the environmental impacts from use of coal, there is a strong push by the government to develop their renewable energy resources, mostly for electricity generation, and progressive targets have been set for the contribution of renewables to overall energy supply – 10% by 2010, 15% by 2020 (*cf* EU goal of 20% by 2020), and 30% by 2030. China has very large renewable energy resources: hydropower 500 GW (world's largest), wind power 1000 GW, biomass 500 Mtce (part of agricultural and forest residues, together with some municipal and industrial wastes). China has the world's largest installed capacity of renewable energy based electricity generation at 37 GW, with the objective of being a world leader in renewable energy business and exports.

There is little doubt that any meaningful reduction in worldwide GHG emissions will need to focus on carbon and energy intensity in the USA and China.

5. Adaption to climate change

Whilst mitigation measures will form an essential part of overall long term strategies to reduce worldwide GHG emissions and hopefully minimise future global temperature

increases arising from these emissions, it is essential that proactive strategies be put in place to adapt to the consequences of current and predicted global warming scenarios.

A variety of adaption options are available, and although some attempts are currently being made to address some of the immediate issues, more extensive action will need to be taken to reduce the vulnerability of some areas and in particular, some of the Asia/Pacific countries.

In addressing this issue it is important to recognise that in addition to economic and practical aspects there are a variety of social, cultural and health aspects that need to be understood and taken into account in planning effective adaption strategies. Some of these aspects will also vary and be unevenly distributed across nations and within societies within a nation.

The provision of financial aid to developing countries from developed nations is key to assisting in reducing environmental degradation and unsustainable resource exploitation and planning for future sustainability. In 2004-5, Australia contributed some $1.2 billion to the top ten nations in the Asia/pacific region [(34)], historically focusing on health, education, governance and infrastructure. As decisions about allocation of future funds in these countries are considered (and especially toward ameliorating the effects of climate change) there will no doubt be conflicts between the use of these funds for mitigation versus adaption options.

It is likely that the priority for the majority of the countries in the Asia/Pacific region will be on adaption strategies in preference to mitigation based on likely short term consequences resulting from already existing conditions. Countries that will contribute increasing GHG emissions and have the ability to take corrective actions to minimise these emissions will no doubt have a different balance in their mitigation/adaption strategies.

It is clear that changes in climate that will seriously affect many of the Asia/pacific countries are unavoidable and inevitable, although the extent of these consequences may be somewhat uncertain. It is essential therefore that a proactive approach be taken to developing and implementing strategies rather than a reactive approach once the resulting consequences have occurred. Benefits are likely to be more substantial if this approach is taken and the identification of long term strategies based on short term experience are likely to be more effective. In some cases and areas, current climatic changes and models from predictions have suggested that benefits may result and it will be important to identify these wherever possible and take advantage of them.

Some examples of possible strategies that have been suggested are summarised in table 3.

The IPCC reports [(1-5)] conclude that neither adaption nor mitigation alone can avoid all the likely impacts of climate change; however they can compliment each other and together can significantly reduce (and possibly take advantage of) the probable effects of climate change.

Coastal Communities
• Identify vulnerable areas, communities, and infrastructure
• Channel future development around "high" "moderate" and "low growth" areas
• Develop coastal zone management plans
• Construct new, or modify existing, coastal defences
• Design infrastructure to accommodate sea-level rise
• Manage progressive retreat from the coastline
Public Health
• Develop early warning systems for extreme weather events (e.g., flood, cyclones, heat waves)
• Establishment or bolstering of public health institutions
• Research and development regarding disease transmission and prevention
• Improving access of individuals and communities to medical and public health agencies
• Education in disease prevention
Ecosystems and Biodiversity
• Establish conservation areas and networks
• Invest in natural resource management plans
• Manage land-use to reduce environmental harm
• Identify at-risk ecosystems and species
• Development of aquaculture and plantation forestry over exploitation of native resources
Water Resources
• Develop new water resources and storages (where possible)
• Invest in climate and catchment monitoring and research
• Rehabilitate existing water supply and transport systems
• Implement demand management measures
• Increase recycling and reuse of waste water
• Invest in water saving technologies/methods
Agriculture
• Change farming practices
• Change timing of farm operations
• Use different crop varieties
• Review governmental and institutional policies and programs
• Research new practices and technologies (e.g., land-use planning, biotechnology)
• Development drought management and relief protocols
Disasters and Emergency Management
• Diversify economic activity to reduce reliance upon climate sensitive sectors
• Develop emergency management plans for climate hazards
• Develop early warning systems for extreme weather events (e.g., flood, cyclones, heat waves)
• Expand availability and use of risk-spreading institutions (e.g., insurance, government assistance)
• Identify critical activities and infrastructure for protection (e.g., health services, energy, transport, communication)
Public Awareness and Education
• Facilitate public awareness about climate change and its potential impacts
• Communicate with public and stakeholders regarding risk management decisions and programs
• Identify pathways for individuals to be active participants in the sustainable management of the environment and its natural resources

Table 3 Some examples of adaption strategies to address regional consequences of climate change [5].

6. What role can the church play?

"In the beginning God created the heavens and the earth...God saw all that he had made, and it was very good"

(Genesis 1:1, 31, NIV)

The scriptures affirm that the "earth is the Lord's and everything in it" (Psalm 26:1, NIV). In Genesis 1:28, God charges humanity to care for the earth by giving humanity "dominion" over it. The word "dominion" is most appropriately translated as "stewardship", since humanity is not the master of the earth but steward to responsibly care for the integrity of creation. God wondrously and lovingly created a world with more than enough resources to sustain generations upon generations of human beings and other living creatures. But humanity is not always faithful in its stewardship. Mindless production and excessive consumption by individuals, corporations and countries have led to continuous desecration of creation, including global warming and other forms of climate change [(35)].

Whilst climate change and its effects are so very important, it is also important that we consider the whole of creation and our holistic attitude to the environment. If we are serious about our theological beliefs then our response to caring for God's creation ought to be a core element of our attitudes rather than an optional extra, and in this consideration to our attitude to global climate change.

The Archbishop of Canterbury, Rowan Williams, has stated:

"For the Church of the 21st century, good ecology is not an optional extra but a matter of justice. It is therefore central to what it means to be a Christian."

The Fifth Mark of Mission of the Worldwide Anglican Communion requires members

To strive to safeguard the integrity of creation and sustain and renew the face of the Earth.

If we are to take our stewardship of the earth seriously, then the church has a very good reason for being committed to do something about the impending climatic change consequences. With a membership of many tens of millions throughout the region we have a great opportunity to demonstrate our commitment to our communities and to those responsible for developing and implementing the broader policies that will ultimately address the consequences of climate change.

In assessing what we might do, it is suggested that we focus our attention on the following aspects;

Awareness

Accepting a responsibility both at a corporate and personal level

Action

Some examples of actions within the church that encompass these aspects are explored below.

The Climate Institute, established in Australia in late 2005, has a five-year goal of raising public awareness and debate about the dangers of global warming and to motivate the country to take positive action. It is a non-partisan, independent group that works with community, business and government to drive innovative and effective climate change solutions. The aim is to research, educate and communicate. The Climate Institute notes that many Christians are speaking up and leading by example. This brochure suggests that in order to ensure a sustainable future for our children and protect the poor from the worst effects of climate change, Congregations, Churches and Governments all need to contribute to the solutions which are to reverse rising pollution, switch to clean energy and lead internationally.

In December 2006, Anglicans in Australia joined with other 16 faith traditions and the Climate Institute to release of "Common Belief: Australia's Faith Communities on Climate Change" [36]. The report highlighted the reality that global warming is not simply a technological problem but a moral issue. As Bishop George Browning said,

"the Christian faith is certainly about personal salvation. But it is more than that: Christianity is first a foremost a concern for the whole created order - biodiversity and business; politics and pollution; rivers, religion and rainforests. The coming of Jesus brought everything of God into the sphere of time and space, and everything of time and space into the sphere of God. All things meet together in him: Jesus is the point of reconciliation. Therefore, if Christians believe in Jesus they must recognise that concern for climate change is not an optional extra but a core matter of faith."

Some of the statements from other contributors highlight the need to accept a responsibility for our actions;

The destruction of the planet has begun through our over-exploitation of our lands and seas. These are not times for blame nor accusations. There is a task ahead of all of us to address the outcomes of our avarice and sloth

Patrick Dodson-Lingiari Foundation

One of the ACL's main concerns is that the consequences of climate change will be felt most heavily by those least able to bear it …Christians will be looking to weigh the degree of determination in each party to tackle it at the next federal election

Australian Christian Lobby

Failure by national governments to respond to climate change may result in unmanageable cost blow-outs, irreversible devastation to ecosystems, the suffering, death and forced migration of the world's poorest and most vulnerable. Wilful environmental degradation is sin. It will attract God's judgement

Baptist Union of Australia

One of the consequences of accepting a responsibility for some action to minimise climate change effects will be an inevitable increase in the cost of some of our services. For example the introduction of a tax based on carbon dioxide emissions will lead to increases in the cost of energy. Other effects such as increasing costs of coal and other fuels will also put pressure on costs in many countries.

Social justice issues will become more important as increasing costs of living impact on those who are less able to absorb these additional costs.

In addition to the adoption of strong mitigation policies and programs, developed nations like Australia must also contribute their share to finance and to help build strong community capacity for adaption and resilience to our neighbouring countries. Whilst current financial aid packages are substantial, the Climate Change and Development Roundtable suggests that not enough is being done to support adaption approaches that will need to be put in place [7].

Oxfam International has estimated that the global costs of the adaption of needs of developing countries will be at least US$50 billion each year, with these costs rising sharply if global emissions are not cut substantially and warming continues beyond $2^{O}C$ [37]. They propose that the USA, EU, Japan, Canada, Republic of Korea and Australia should contribute over 95% of the finance needed, given historic responsibility and capacity to pay. It is estimated that Australia's contribution should be 2.9% of the total cost or about US$1.45 billion per annum.

It is unlikely that developed countries like Australia will be able to provide the large amount of money needed for adaption for the world's poorest countries through voluntary contributions alone and some form of more reliable and predictable funding might come from greenhouse gas trading schemes, levies on greenhouse gas generation activities or from international protocol schemes. The establishment and administration of such funding arrangements will continue to be a challenge for world leaders.

In developing appropriate adaption actions, it will be important for local communities to participate in planning, decision making and implementation of agreed actions. Integration of these plans into existing and new social infrastructure and policies will assist in minimising conflicts and duplication of efforts.

The need for relocation of people affected by rising sea levels raises questions of who is responsible for paying these costs, and how to prevent cultures being lost when culturally distinct groups are displaced from their homes. Australia will be able to play a key role in helping any Pacific island neighbours who are forced to relocate.

Disseminating information, sharing ideas and creating awareness of actions and projects initiated by church groups within the community is important. The Australian Anglican Environment Network (AAEN) is one example of an association of dioceses within the Anglican Church of Australia which have taken up their responsibility to the Fifth Mark of Mission of the Worldwide Anglican Church by establishing Diocesan Environment Commissions (www.aaen.com.au). This website is designed to excite people with the many possibilities open to us and to encourage active grass roots response throughout the Australian Anglican Church by sharing information on what dioceses are doing, what leaders in the field are saying and providing links to action across the world.

The web site of the Environment Working Group of General Synod (www.environment.perth.anglican.org) also has more resources on the environment.

The Season of Creation is an initiative that seeks to explore new ways in which we have an opportunity to celebrate God, the Creator.

About the season of creation initiative

In the seasons of Advent, Epiphany, Lent and Easter we celebrate the life of Christ. In the season of Pentecost we celebrate the Holy Spirit. For four Sundays in September, prior to St Francis of Assisi Day, we join in celebrating with Christ the wonders of creation. In the liturgy, we follow the lead of the psalm writers and celebrate with creation — with the forests, the rivers and the fields, which praise the Creator in their own way. Bible readings focus especially on the story of Earth, which complements the story of God and the story of humanity in the Scriptures. We commit ourselves to a ministry of healing Earth, with Christ and creation as our partners. www.**season**of**creation**.com

The role that young people can play in promoting awareness and action must not be underestimated and must be encouraged and promoted.

Environmental Project,
Godly Play, St. Alban's Anglican Church, Charlestown, NSW

The young people from St Alban's Church in Charlestown performed an environmental play aimed at encouraging the congregation to act responsibly and reduce their impact on the environment. Arising from the play, they produced a series of fridge magnets based on drawings that sought to illustrate some of the key themes. Money raised from selling the magnets is being saved to fund an environmental project within the parish.

Many opportunities exist at an individual level to demonstrate our commitment to accepting a personal responsibility for our stewardship of the earth and to reduce our greenhouse gas footprint. Some simple examples (in an Australian context) include the use of energy efficient fluorescent light globes and appliances, installation of solar hot water systems, walking/cycling instead of driving our car, reduced use of water.

A resolution from the central committee of the World Council of Churches, meeting in Geneva, Switzerland, 13-20 February 2008 issues a number of challenges that might for the basis for future actions in many of our churches. The resolution (in part)[38];

Urgently calls the churches to strengthen their moral stand in relationship to global warming and climate change, recalling its adverse effects on poor and vulnerable communities in various parts of the world, and encourages the churches to reinforce their advocacy towards governments, NGOs, the scientific community and the business sector to intensify cooperation in response to global warming and climate change;

Calls for a profound change in the relationship towards nature, economic policies, consumption, production and technological patterns.

Encourages member churches, specialized ministries and other ecumenical partners to:

a) share and further develop creative ways of practicing ecologically respectful relationships within the human community and with the earth;

b) share knowledge and affordable technology that promote environmentally friendly lifestyles;

c) monitor the ecological footprints of individuals, parishes, corporations and states and take other steps to mitigate climate change and global warming;

Urges member churches to observe through prayers and action a special time for creation, its care and stewardship, starting on September 1st every year, to advocate for the plight of people and communities of the Pacific, especially in the low lying atolls of Kiribati and Tuvalu, and to find specific ways to show our ecumenical solidarity with those most at risk;

Requests theological schools, seminaries and academies to teach stewardship of all creation in order to deepen the ethical and theological understanding of the causes of global warming and climate change and of the sustainable lifestyle that is needed as a response;

Promotes the exploration of inter-religious and inter-cultural avenues for cooperation and constructive response, such as the inter-religious summit planned by the Church of Sweden, ensuring a better stewardship of creation and a common witness through concrete actions.

The challenge of a greater awareness, acceptance of a responsibility and putting actions in place at a personal and corporate level to minimise the effects of climate change and to address the many consequences is before us all.

7. References

1 IPCC (Intergovernmental Panel on Climate Change). (2007). Climate Change 2007: Synthesis Report- AR4-17 Nov. Valencia, Spain. (http://www.ipcc.ch/)
2 IPCC (Intergovernmental Panel on Climate Change). (2007). Climate Change 2007: Working Group I Report-The Physical Science Basis. (http://www.ipcc.ch/)
3 IPCC (Intergovernmental Panel on Climate Change). (2007). Climate Change 2007: Working Group II Report- Impacts, Adaption and Vulnerability. (http://www.ipcc.ch/)
4 IPCC (Intergovernmental Panel on Climate Change). (2007). Climate Change 2007: Working Groups III Report- Mitigation of Climate Change. (http://www.ipcc.ch/)
5 CSIRO (2006) Climate Change in the Asia/Pacific Region. (www.csiro.au/files/files/p9xj.pdf)

6 Working Group on Climate Change and Development. Up in Smoke? Asia and the Pacific. (www.oxfam.org/en/files/up_in_smoke_asia_nov07.pdf)
7 The Climate Change and Development Roundtable (2007). Climate Change: Impacts and Australia's role in Assisting our Most Vulnerable Neighbours. (http://www.ccdr.org.au/CCDR_report.pdf)
8 U.S. National Oceanographic and Atmospheric Administration's Global Monitoring Division (http://www.esrl.noaa.gov/gmd/ccgg/trends/)
9 Siegenthaler, U., Stocker, T.F., Monnin, E., Luthi, D., Schwander, J., Stauffer, B., Raynaud, D., Barnola, J.-M., Fisher, H., Masson-Delmotte, V., and Jouzel, J. (2005). Stable carbon cycle– climate relationship during the late Pleistocene. Science 310, 1313-1317.
10 Spahni, R., Chappellaz, J., Stocker, T.F., Loulergue, L., Hausammann, G., Kawamura, K., Fluckiger, J., Schwander, J., Raynaud, D., Masson-Delmotte, V., and Jouzel, J. (2005). Atmospheric methane and nitrous oxide of the late Pleistocene from Antarctic ice cores. Science 310, 1317-1321.
11 Goddard Institute for Space Studies. Global Temperature Trends: (http://data.giss.nasa.gov/gistemp/2005/)
12 Nova-Science in the News-Australian Academy of Science (http://www.science.org.au/nova/082.htm)
13 The Royal Society (http://royalsoc.ac.uk/displaypagedoc.asp)
14 http://www.soes.soton.ac.uk/staff/tt/eh/future.html
15 Carbon Dioxide Information Center, Oak ridge National laboraotory (http://cdiac.ornl.gov/ftp/trendsco2/lawdone.combined.dat)
16 (http://cdiac.ornl.gov/ftp/ndp001/maunaloa.co2)
17 Henderson-Sellers, A., Zhang, H., Berz, G., Emanuel, K. Gray, W., Landsea, C., Holland, G., Lighthill, J., Shieh, S.-L., Webster, P., and McGuffie, K. (1998). Tropical cyclones and global climate change: A post-IPCC assessment. Bulletin of the American Meteorological Society 79, 19-38.
18 Rogers, D.J., and Randolph, S.E. (2000). The global spread of malaria in a future warmer world. Science 289, 1763-1766.
19 Hales, S., de Wet, N., Maindonald, M., and Woodward, A. (2002). Potential effects of population and climate changes on global distribution of dengue fever: An empirical model. The Lancet 360, 830-834.
20 WHO (World Health Organisation). (1999). El Niño and Health. Doc.No. WHO/SDE/PHE/99.4. Geneva, Switzerland.
21 Knowlton, K., Rosenthal, J.E., Hogrefe, C., Lynn, B., Gaffin, S., Goldberg, R., Rosenzweig, C., Civerolo, K., Ku, J.-Y., and Kinney, P.L. (2004). Assessing ozone-related health impacts under a changing climate. Environmental Health Perspectives 112, 1557-1563.
22 UNEP (United Nations Environment Programme) and C4. (2002). The Asian Brown Cloud: Climate and other Environmental Impacts. United Nations Environment Program, Nairobi, Kenya. (http://www.rrcap.unep.org/abc/impactstudy/)
23 Steffen, W., and Canadell, P. (2005). Carbon Dioxide Fertilisation and Climate Change Policy. Report prepared for the Australian Greenhouse Office, Department of the Environment and Heritage, Canberra, Commonwealth of Australia, 33 pp.
24 Tao, F., Yakozawa, M., Hayashi, Y., and Lin, E. (2003). Future climate change, the agricultural water cycle, and agricultural production in China. Agriculture, Ecosystems and Environment 95, 203-215.
25 Lie, H., Li, X., Fisher, G., and Sun, L. (2004). Study on the impacts of climate change on China's agriculture. Climatic Change 65, 125-148
26 Erda, L., Wei, X., Hui, J., Yinlong, X, Yue, L., Liping, B., and Liyong, X. (2005). Climate change impacts on crop yield and quality with CO2 fertilization in China. Philosphical

Transactions of the Royal Society B 360, 2149-2154.
27 IPCC (2002) Climate Change and Biodiversity, [H. Gitay, Suárez, A., Watson, RT., and Dokken, D.J. (eds.)], Technical Paper V, Intergovernmental Panel on Climate Change, Geneva, Switzerland, 86 pp.
28 IPCC (Intergovernmental Panel on Climate Change). (1998). The Regional Impacts of Climate Change: An Assessment of Vulnerability. Special Report of the IPCC Working Group II. [R.T. Watson, M.C. Zinyowera, R.H. Moss and D.J. Dokken (eds.)]. Cambridge University Press, Cambridge, UK.
29 Jayasuriya, S., Steele, P., Weerakoon, D., Knight-John, M., and Arunatilake, N. (2006). Post-Tsunami Recovery: Issues and Challenges in Sri Lanka. Asian Development Bank Institute, Tokyo, Japan.(http://www.adbi.org/files/2006.06.rp71.tsunami.recovery.english.pdf)
30 Data obtained from the Climate Analysis Indicators Tool of the World Resources Institute. (http://cait.wri.org/).
31 Netherlands Environmental Assessment Agency, 22 June 2007;
(http://www.mnp.nl/en/service/pressreleases/2007/20070622ChineseCO2emissionsinperspective.html)
32 The Natural Edge Project. Energy Transformed: Sustainable Energy Solutions for Climate Change Mitigation
(http://www.naturaledgeproject.net/Sustainable_Energy_Solutions_Portfolio.aspx)
33 Australia and China partner to develop carbon capture and storage technologies (2008). (biopact.com/2008/03/china-and-australia-sign-clean-coal.html)
34 AUSAid (2005). Annual Report 2005-2005. Volume 2. Australian Agency for International Development, Canberra, Commonwealth of Australia.
(http://www.ausaid.gov.au/anrep05/pdf/anrep04_05.pdf).
35 World Council of Churches. March 2008. Climate Change newsletter #44
36 The Climate Institute (2006) Common belief-Australia's faith communities on climate change (http://www.climateinstitute.org.au/images/reports/commonbelief.pdf)
37 Oxfam International. 2007. Adapting to Climate Change what's needed in poor countries, and who should pay, Oxfam Briefing Paper 104.
38 http://www.oikoumene.org/en/resources/documents/central-committee/geneva-2008/reports-and-documents/public-issues/minute-on-global-warming-and-climate-change.html