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Building a Sustainable Future Free from Extreme Poverty:
Priorities for APEC

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Note: The views expressed in this report are those of the authors and do not necessarily reflect in detail those of every individual member agency of the Make Poverty History coalition.

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Brett Parris

1. Introduction

Climate change is fundamentally a development problem. As such, it is central both to human security and to APEC. The greenhouse gas emissions were caused predominantly by the industrialisation and land clearing of today's rich countries, and they will be increased further by their continued growth and by the development of today's poorer countries. The solutions will also be developmental – involving significant reductions in emissions, increases in energy efficiency, less carbon-intensive means of production and energy generation, reforestation and prevention of further deforestation, and assistance to those most vulnerable to changing weather patterns, sea level rise and extreme weather events. It is difficult to overstate the importance of climate change for humanity, for the poor and for APEC. There are times for deliberation and for hoping for the best – for not wanting to sound "alarmist". But some things are alarming. There comes a time for recognising that we know enough to know that we have overstepped the mark; for acknowledging that we have no right to be taking the reckless risks that we are taking; and for issuing an urgent clarion call for action. That time is now.

There comes a time for recognising that we know enough to know that we have overstepped the mark; for acknowledging that we have no right to be taking the reckless risks that we are taking; and for issuing an urgent clarion call for action. That time is now.

2. The Science of Climate Change

2.1 Linear and nonlinear systems

To appreciate the risks of interfering with the climate, we need to understand the difference between linear and nonlinear systems. With linear systems, a slow, gradual and predictable cause will tend to have a slow, gradual and predictable effect. But with nonlinear systems, slow, gradual causes can result in sudden and quite radical effects. The idea of the threshold, or tipping-point, is one of the most important concepts for understanding the behaviour of nonlinear systems. Often little seems to be happening until a critical threshold is crossed, and then suddenly, the system 'tips' and rapid changes ensue.

Why is this distinction between linear and nonlinear systems so important? Because the Earth's climate is not a simple linear system, but a highly complex nonlinear system with the potential to lurch from one stable state to another. In particular, the emergence from the last ice age was characterised by dramatic oscillations, or 'flickering' between cold and warm periods.[1]

2.2 Ancient climate records

Sea levels have also risen and fallen dramatically in the past – sometimes quite rapidly. Between around 130,000 to 118,000 years ago for example, at the height of the last interglaciation (the period between ice ages) the sea levels were some four to seven metres higher than they are now.[2] This corresponds to what would occur if the Greenland Ice Sheet were to melt. But more extreme levels have also occurred in the past. Sea levels were around 73 metres higher some 35 million years ago when CO_2 levels were around 1250 ppm and there was no permanent ice on the planet. More recently, they were around 130 metres lower during the Last Glacial Maximum

21,000 years ago when CO_2 levels were around 185 ppm.[3] Figure 1 shows the relationships between carbon dioxide (CO_2), methane (CH_4) and temperature for the last 430,000 years, compiled from data from Antarctic ice cores and measurements over the last century. Temperature changes and changes in the concentrations of the two greenhouse gases track each other closely, and in fact have exhibited a strong coupling for the last 650,000 years.[4]

Two important facts emerge from this data. Firstly, when temperatures have begun to increase again in the Antarctic after ice ages, the temperatures rose first, followed by the CO_2, with lags ranging from 200 to 2000 years.[5] Climate change sceptics have often interpreted the fact that temperatures led the CO_2 increases as proving that increases in CO_2 do not contribute to global warming. In fact it proves nothing of the sort. What it demonstrates is that CO_2 was not the forcing that drove the *initial* warming after periods of glaciation in Antarctica. The initial phase of warming however, is only a fraction of the total warming period. For example, during the so-called 'termination III', some 240,000 years ago, the initial warming was only around 800 years out of a total warming period of some 5000 years. The rising CO_2 commonly amplifies the initial effects, making the warming periods longer and warmer than they would otherwise have been without the extra CO_2. The second key fact to emerge from Figure 1 is that in the past century we have sent CO_2 and methane concentrations off the chart – far beyond anything the Earth has experienced for the past 430,000 years.

The Earth's climate is not a simple linear system, but a highly complex nonlinear system with the potential to lurch from one stable state to another.

The long mild summer which we have enjoyed for about the past 8000 years or so is one of the most stable climatic periods in the Earth's recent history. We are now in the process of upsetting that stability without fully understanding where it might ultimately lead, except we already know that it won't be good. We have experienced periods of dramatic cooling before in ancient human history, but for the last 650,000 years the Earth has never experienced a warming greater than about 2°C above current levels.

The rapidly rising greenhouse gas concentrations are pushing us into territory that has remained uncharted for hundreds of thousands of years. By treating such a complex nonlinear system in such a cavalier manner, we are effectively poking a very large gorilla with a sharpened stick.

2.3 Results from the 2007 Fourth Assessment Report of the IPCC

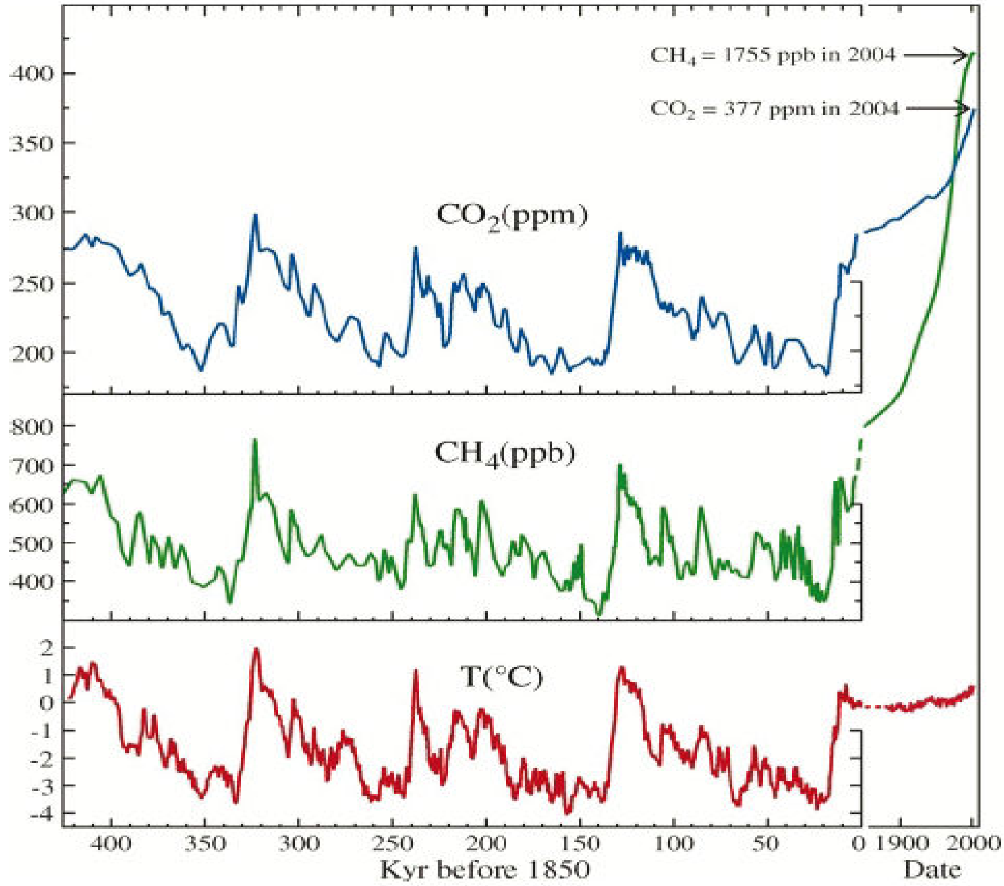
In 2005, the national academies of science of all G8 countries (Canada, France, Germany, Italy, Japan, Russia, the UK and the USA) along with the national academies of Brazil, China and India, released an unprecedented joint statement entitled *Global Response to Climate Change*.[6] The statement clearly warned that "climate change is real" and that: "The scientific understanding of climate change is now sufficiently clear to justify nations taking prompt action."

Between February and May 2007, the IPCC's three Working Groups lodged their reports, each with a *Summary for Policymakers*, as part of the IPCC's Fourth Assessment. The reports gave the strongest warnings yet of the dangers of continuing to disturb the world's climate. These findings are so significant that we quote some of them here in the next three sections.

2.3.1 From Working Group I: The Science of Climate Change[7]:

- The global atmospheric concentration of carbon dioxide has increased from a pre-industrial value of about 280 ppm (parts per million) to 379 ppm in 2005. [p. 2]

Figure 1: The relationships between carbon dioxide (CO_2), methane (CH_4) and temperature for the last 430,000 years identified from Antarctic ice cores and from data from the last century. Note that temperature is measured in terms of deviations from the average from 1880-1899, which is set to zero. Carbon dioxide is measured in parts per million (ppm) and methane is measured in parts per billion (ppb). Kyr = "thousands of years".[8]



- The global atmospheric concentration of methane has increased from a pre-industrial value of about 715 ppb (parts per billion) to … 1774 ppb in 2005. [p. 4]

- The understanding of anthropogenic warming and cooling influences on climate has improved … leading to very high confidence that the globally averaged net effect of human activities since 1750 has been one of warming. [p. 5]

- Warming of the climate system is unequivocal. [p. 5]

- Eleven of the last twelve years (1995-2006) rank among the 12 warmest years in the instrumental record of global surface temperature (since 1850). [p. 5]

- The total temperature increase from 1850 – 1899 to 2001 – 2005 is 0.76 [0.57 to 0.95]°C.

- Global average sea level rose at an average rate of 1.8 mm per year over 1961 to 2003. The rate was faster over 1993 to 2003, about 3.1 mm per year. The total 20th century rise is estimated to be 0.17 m. [p. 7]

- Numerous long-term changes in climate have been observed. These include changes in Arctic temperatures and ice, widespread changes in precipitation amounts, ocean salinity, wind patterns and aspects of extreme weather including droughts, heavy precipitation, heat waves and the intensity of tropical cyclones. [p. 8]

- The last time the polar regions were significantly warmer than present for an extended period (about 125,000 years ago), reductions in polar ice volume led to 4 to 6 metres of sea-level rise. [p. 10]

- 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. [p. 10]

- The equilibrium climate sensitivity … is defined as the global average surface warming following a doubling of carbon dioxide concentrations. It is likely to be in the range 2 to 4.5°C with a best estimate of about 3°C, and is very unlikely to be less than 1.5°C. [p. 12]

- Since IPCC's first report in 1990, assessed projections have suggested global averaged temperature increases between about 0.15 and 0.3°C per decade for 1990 to 2005. This can now be compared with observed values of about 0.2°C per decade. [p. 13]

- Table SPM-3, *Projected globally averaged surface warming and sea level rise at the end of the 21st century*. This table, not reproduced here, shows that projected sea-level rises range from 0.18 m with a temperature rise of 1.1°C under the best case scenario of rapid emissions reduction, to 0.59 m with a temperature rise of up to 6.4°C under the worst case 'business as usual' scenario. [p. 13] *Note: The caveat in the following bullet point from p. 17 and the new findings on ice sheet dynamics discussed in Section 2.3 suggest that this 0.59 m upper bound may be unduly optimistic.*

Observational evidence shows that many natural systems are being affected by regional climate changes, particularly temperature increases.

- It is *very likely* that hot extremes, heat waves, and heavy precipitation events will continue to become more frequent. [p. 16]

- Based on a range of models, it is *likely* that future tropical cyclones (typhoons and hurricanes) will become more intense, with larger peak wind speeds and more heavy precipitation associated with ongoing increases of tropical SSTs [sea surface temperatures]. [p. 16]

- Dynamical processes related to ice flow not included in current models but suggested by recent observations could increase the vulnerability of the ice sheets to warming, increasing future sea-level rise. Understanding of these processes is limited and there is no consensus on their magnitude. [p. 17]

2.3.2 From Working Group II: Impacts, Adaptation and Vulnerability[9]:

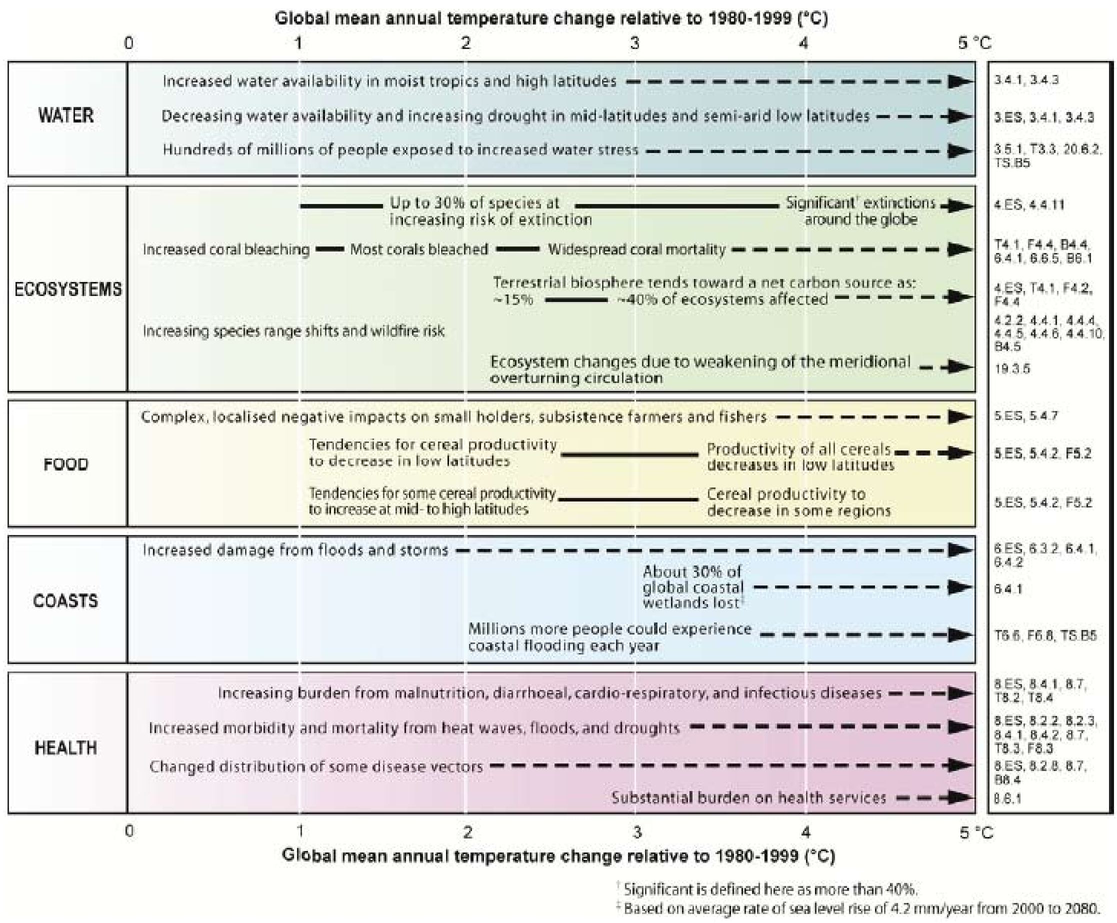
- Observational evidence from all continents and most oceans shows that many natural systems are being affected by regional climate changes, particularly temperature increases. [p. 1]

- The uptake of anthropogenic carbon since 1750 has led to the ocean becoming more acidic. [p. 2]

- A global assessment of data since 1970 has shown it is likely that anthropogenic warming has had a discernible influence on many physical and biological systems. [p. 2]

- In the Sahelian region of Africa, warmer and drier conditions have led to a reduced length of growing season with detrimental effects on crops. In southern Africa, longer dry seasons and more uncertain rainfall are prompting adaptation measures. [p. 3]

Figure 2: "Illustrative examples of global impacts projected for climate changes (and sea-level and atmospheric carbon dioxide where relevant) associated with different amounts of increase in global average surface temperature in the 21st century. The black lines link impacts, dotted arrows indicate impacts continuing with increasing temperature. Entries are placed so that the left hand side of text indicates approximate onset of a given impact. … All entries are from published studies recorded in the chapters of the Assessment. Sources are given in the right hand column of the Table. Confidence levels for all statements are high."[10]



- **Drought**-affected areas will likely increase in extent. Heavy precipitation events, which are very likely to increase in frequency, will augment flood risk. [p. 5]

- In the course of the century, **water** supplies stored in glaciers and snow cover are projected to decline, reducing water availability in regions supplied by meltwater from major mountain ranges, where more than one-sixth of the world population currently lives. [p. 5]

- Approximately 20-30% of plant and animal species assessed so far are likely to be at increased risk of **extinction** if increases in global average temperature exceed 1.5-2.5°C. [p. 6]

- Many millions more people are projected to be flooded every year due to sea-level rise by the 2080s. [p. 7]

- Projected climate change-related exposures are likely to affect the **health** status of millions of people, particularly those with low adaptive capacity, through: increases in malnutrition and consequent disorders, with implications for child growth and development; increased deaths, disease and injury due to heat waves, floods, storms, fires and droughts; the increased burden of diarrhoeal disease; … the altered spatial distribution of some infectious disease vectors. [p. 7]

- **Africa**: By 2020, between 75 and 250 million people are projected to be exposed to an increase of water stress due to climate change. … Agricultural production, … is projected to be severely compromised by climate variability and change. … New studies confirm that Africa is one of the most vulnerable continents to climate variability and change because of multiple stresses and low adaptive capacity. [p. 8]

- **Asia**: Glacier melt in the Himalayas is projected to increase flooding, and rock avalanches from destabilised slopes, and to affect water resources within the next two to three decades. This will be followed by decreased river flows as the glaciers recede. … Freshwater availability in Central, South, East and Southeast Asia, … is projected to decrease due to climate change which … could adversely affect more than a billion people by the 2050s. [p. 8] … Endemic morbidity and mortality due to diarrhoeal disease primarily associated with floods and droughts are expected to rise in East, South and Southeast Asia .... Increases in coastal water temperature would exacerbate the abundance and/or toxicity of cholera in South Asia. [p. 9]

- **Latin America**: By mid-century, increases in temperature and associated decreases in soil water are projected to lead to gradual replacement of tropical forest by savannah in eastern Amazonia. … In drier areas, climate change is expected to lead to salinisation and desertification of agricultural land. Productivity of some important crops is projected to decrease and livestock productivity to decline, with adverse consequences for food security.… Changes in precipitation patterns and the disappearance of glaciers are projected to significantly affect water availability for human consumption, agriculture and energy generation. [p. 10]

Freshwater availability in Central, South, East and Southeast Asia, is projected to decrease due to climate change which could adversely affect more than a billion people by the 2050s.

- **Polar regions**: Reductions in thickness and extent of glaciers and ice sheets, and changes in natural ecosystems with detrimental effects on many organisms including migratory birds, mammals and higher predators. In the Arctic, additional impacts include reductions in the extent of sea ice and permafrost, increased coastal erosion, and an increase in the depth of permafrost seasonal thawing. [p. 11]

- **Small islands**: Small islands … have characteristics which make them especially vulnerable to the effects of climate change, sea-level rise and extreme events. … Sea-level rise is expected to exacerbate inundation, storm surge, erosion and other coastal hazards, thus threatening vital infrastructure, settlements and facilities that support the livelihood of island communities. … Climate change is projected by the mid-century to reduce water resources in many small islands … to the point where they become insufficient to meet demand during low rainfall periods. [p. 11]

- **Very large sea-level rises** that would result from widespread deglaciation of Greenland and West Antarctic ice sheets imply major changes in coastlines and ecosystems, and inundation of low-lying areas, with greatest effects in river deltas. … The complete melting of the Greenland ice sheet and the West Antarctic ice sheet would lead to a contribution to sea-level rise of up to 7 m and about 5 m, respectively. [p. 15]

- **Adaptation** will be necessary to address impacts resulting from the warming which is already unavoidable due to past emissions. [p. 17]

2.3.3 From Working Group III: Mitigation of Climate Change[11]:

- Energy efficiency options for new and existing **buildings** could considerably reduce CO_2 emissions with net economic benefit. … By 2030, about 30% of the projected GHG emissions in the building sector can be avoided with net economic benefit. [p. 19]

- **Agricultural practices** collectively can make a significant contribution at low cost to increasing soil carbon sinks, to GHG emission reductions, and by contributing biomass feedstocks for energy use. [p. 20]

- In order to **stabilise the concentration of GHGs** in the atmosphere, emissions would need to peak and decline thereafter. The lower the stabilisation level, the more quickly this peak and decline would need to occur. [p. 22]

- Irrespective of the scale of mitigation measures, adaptation measures are necessary. [p. 33]

- Climate change policies related to **energy efficiency and renewable energy** are often economically beneficial, improve energy security and reduce local pollutant emissions. [p. 33]

The IPCC's 2007 reports demonstrate unequivocally that climate change is a clear and present danger to humanity and to hundreds of thousands of other species.

2.3.4 Conclusion on the IPCC's 2007 Fourth Assessment Reports

The IPCC's latest reports demonstrate unequivocally that climate change is a clear and present danger to humanity and to hundreds of thousands of other species.[12] Temperatures have been increasing by some 0.2°C per decade since 1990, sea-level rise has accelerated since 1993, and 11 of the 12 warmest years on record are after 1995. Major environmental changes have already been observed. These assessments are concerning enough, but studies published since the cut-off period for consideration by the IPCC suggest that it may have underestimated the pace and scope of climate change.

2.4 Recent scientific developments

There have been a number of studies released since the drafting process for this round of IPCC reports concluded which suggest that the IPCC has erred on the side of caution, and if anything, has underestimated the pace of change. A comparison of recent climate observations with model projections published in May 2007 reveals that "the global mean surface temperature increase (land and ocean combined) … is 0.33°C for the 16 years since 1990, which is in the upper part of the range predicted by the IPCC." On sea levels, "The satellite data show a linear trend of 3.3 ± 0.4mm/year (1993-2006) and the tide gauge reconstruction trend is slightly less, whereas the IPCC projected a best-estimate rise of 2 mm/year." The authors conclude that, "Overall, these observational data underscore the concerns about global climate change.

Previous projections, as summarised by IPCC, have not exaggerated but may in some respects even have underestimated the change, in particular for sea level."[13]

One contributor to sea-level rise is the Greenland Ice Sheet, which is melting faster than expected.[14] Until quite recently it was thought that major ice sheets such as those in Greenland and Antarctica were relatively stable, melting slowly and predictably over centuries or millennia. This understanding has been challenged recently, but the growing concern of glaciologists is not adequately reflected even in the latest models considered by the IPCC.[15] As Vaughan and Arthern observe, "the IPCC's projections specifically exclude the contribution that could arise from rapidly changing flow in ice sheets, especially in Greenland and West Antarctica."[16] Another recent paper warned:

> [I]ce sheets have contributed meters above modern sea level in response to *modest* warming, with peak rates of sea-level rise possibly exceeding 1 m/century. Current knowledge cannot rule out a return to such conditions in response to continued greenhouse gas emissions. Moreover, a threshold triggering many meters of sea-level rise could be crossed well before the end of this century, particularly given that high levels of anthropogenic soot may hasten future ice-sheet melting …, the Antarctic could warm much more than 129,000 years ago [when sea levels were 4-6 m higher] … and future warming will continue for decades and persist for centuries even after the forcing [the gas levels causing climate change] is stabilized.[17]

The most recent estimates of global CO_2 emission rates have shown that we are exceeding the upper bounds of the IPCC's previous emission projections.

The extent of Arctic sea ice at the end of the melt season in September was also shown in May 2007 to be declining much faster than expected. The observed trend from 1953 to 2006 was stronger than the IPCC model predictions. Current summer minima are some 30 years ahead of average model predictions, making it likely that the Arctic Ocean will be ice-free each September well before the end of this century.[18]

The most recent estimates of global CO_2 emission rates, published in June 2007, have shown that we are exceeding the upper bounds of the IPCC's previous emission projections:

> CO_2 emissions from fossil-fuel burning and industrial processes have been accelerating at a global scale, with their growth rate increasing from 1.1% y^{-1} [per year] for 1990-1999 to > [more than] 3% y^{-1} [per year] for 2000-2004. The emissions growth rate since 2000 was greater than for the most fossil-fuel intensive of the Intergovernmental Panel on Climate Change emissions scenarios developed in the late 1990s. … No region is decarbonizing its energy supply. The growth rate in emissions is strongest in rapidly developing economies, particularly China. Together, the developing and least-developed economies (forming 80% of the world's population) accounted for 73% of global emissions growth in 2004 but only 41% of global emissions and only 23% of global cumulative emissions since the mid-18th century. The results have implications for global equity.[19]

The acceleration in CO_2 emissions is especially concerning since a recent reassessment of the threshold for "dangerous" climate change suggests that warming greater than about 1°C above 2000 levels, or around 1.7°C above 1850 levels, "has effects that may be highly disruptive". Previously it had been thought that "dangerous" climate change would ensue only after the 2°C line had been crossed.[20]

Finally, another recent study has put paid to the alternative theory that variations in solar luminosity are responsible for the recent warming rather than greenhouse gases produced by humans, concluding: "Over the past 20 years, all the trends in the Sun that could have had an influence on the Earth's climate have been in the opposite direction to that required to explain the observed rise in global mean temperatures."[21]

In summary, several of the most recent studies not only confirm the IPCC's bleak outlook, but suggest it has been overly optimistic in its assessment.[22] Jim Hensen, Director of NASA's Goddard Institute for Space Studies in New York, has gone so far as to argue that the latest evidence, particularly on ice sheets, is of such concern that we cannot afford to wait for the next IPCC assessment report to digest it.[23]

3. The Economics of Climate Change

If the scientists are still grappling with issues as fundamental as ice-sheet stability, it should come as no surprise that the economics of climate change is even more controversial. Nicholas Stern's 2006 report for the UK government on *The Economics of Climate Change* advocated early action and deep emission cuts. The report was criticised by some for using low discount rates, meaning that the report's analysis placed a higher value on the future than some economists and investors feel is warranted. But a low discount rate is quite appropriate for analysis involving broad social considerations and numerous externalities which are not adequately captured in private benefits and prices and market rates of return on capital.[24]

Several of the most recent studies not only confirm the IPCC's bleak outlook, but suggest it may be overly optimistic in its assessment.

3.1 The IPCC on the Economics of Climate Change

The IPCC's Working Groups released their summaries for policymakers several months after Stern's report. The *Summary for Policymakers* of Working Group III[25] contains a number of statements on the economics of climate change:

- In **2050 global average macro-economic costs** for multi-gas mitigation towards stabilisation between 710 and 445 ppm CO_2-eq, are between a 1% gain to a 5.5% decrease of global GDP. [p. 27]

- Integrated assessment of the **economic costs and benefits** of different mitigation pathways shows that the economically optimal timing and level of mitigation depends upon the uncertain shape and character of the assumed climate change damage cost curve. To illustrate this dependency:
  - if the climate change damage cost curve grows slowly and regularly, and there is good foresight (which increases the potential for timely adaptation), later and less stringent mitigation is economically justified; [p. 27]
  - alternatively if the damage cost curve increases steeply, or contains nonlinearities (e.g. vulnerability thresholds or even small probabilities of catastrophic events), earlier and more stringent mitigation is economically justified. [pp. 27-28]

- **Climate sensitivity is a key uncertainty** for mitigation scenarios that aim to meet a specific temperature level. Studies show that if climate sensitivity is high then the timing and level of mitigation is earlier and more stringent than when it is low. [p. 28]

- Delayed emission reductions lead to investments that lock in more emission-intensive infrastructure and development pathways. This significantly constrains the opportunities to achieve lower stabilisation levels … and increases the risk of more severe climate change impacts … Regulations and standards generally provide some certainty about emission levels. … Taxes and charges can set a price for carbon, but cannot guarantee a particular level of emissions. [p. 28]

- **Tradable permits** will establish a carbon price. The volume of allowed emissions determines their environmental effectiveness, while the allocation of permits has distributional consequences. … **Financial incentives** (subsidies and tax credits) are frequently used by governments to stimulate the development and diffusion of new technologies. While economic costs are generally higher than for the instruments listed above, they are often critical to overcome barriers. [p. 29]

- Policies that provide a real or implicit **price of carbon** could create incentives for producers and consumers to significantly invest in low-GHG products, technologies and processes. [p. 29]

- **Government support** through financial contributions, tax credits, standard setting and market creation is important for effective technology development, innovation and deployment. Transfer of technology to developing countries depends on enabling conditions and financing. [p. 32]

- Public benefits of RD&D [Research, Development & Demonstration] investments are bigger than the benefits captured by the private sector, justifying **government support of RD&D**. [p. 32]

The IPCC concluded that a doubling of CO_2 levels from the pre-industrial level of 280 ppm to 560 ppm would result in a temperature increase of between 2°C and 4.5°C, with a best estimate of 3°C.[26] By 2005 CO_2 levels had risen to 379 ppm.[27] To prevent temperature increases beyond 2.0 - 2.4°C, it is necessary to stabilise CO_2 levels at concentrations no higher than 350-400 ppm, (or 445-490 ppm CO_2-equivalent when the other greenhouse gases are included). This requires global CO_2 emissions to peak by 2015 at the latest, and by 2050 to be between 85% and 60% *below* their levels in 2000.[28]

The economic costs of early action to stabilise greenhouse gas concentrations at levels to prevent dangerous climate change are likely to be modest, with costs of abatement increasing the longer action is delayed.[29] The IPCC estimated that stabilising greenhouse gases in the range of 445-535 ppm CO_2-equivalent could result in a global GDP up to 5.5% lower by 2050 than the baseline 'do nothing' projection. But even a 5.5% reduction in global GDP equates to a reduction of less than 0.12 percentage points of annual GDP growth between now and 2050.[30]

To tackle climate change we would have to wait until around 2052 to be as rich as we would have been in 2050 if we had done nothing and taken the risk with the world's climate.

When a study concludes that mitigation would cost 5.5% of GDP compared to a baseline forecast, it is not saying we need to immediately write a cheque for this amount. The actual costs would be a combination of direct costs requiring payment and indirect opportunity costs in the form of economic opportunities foregone. Both kinds of costs would be incurred over many years and would result in a barely perceptible reduction in the *growth rate* of GDP such that we would end up 5.5% poorer by 2050 than under the baseline projection. Since 5.5% is close to annual economic growth figures, this means that to tackle climate change we would have to wait until around 2052 to be as rich as we would have been in 2050 if we had done nothing and taken the risk with the world's climate.

3.2 Uncertainty in modelling the economics of climate change

Despite the impressive degree of consensus among scientists on human-induced climate change, significant areas of uncertainty still exist, including: the 'climate sensitivity' (the average surface temperature change induced by a doubling of CO_2), the dynamics of the ice sheets, and the possibilities of large volumes of methane being released from melting Arctic permafrost and from the methane deposits below the ocean floors. These uncertainties are of little comfort though, because they tell us that the risks are actually larger than we have previously thought. We seem to have a reasonable grasp of the minimum likely climatic effects, with great uncertainty about the maximum effects.

Even without these scientific uncertainties, economic models at the best of times are not terribly good at modelling long-term developments involving changing climatic conditions, changing human capabilities, technological innovations, the responses of financial systems, and the implications of repeated extreme weather events.[31] Given that the current crop of economic models do not even incorporate the recent scientific developments on the potential faster melting of ice sheets, we should treat with scepticism scaremongering over the costs of mitigation relative to doing nothing. In particular, the base-case projections for GDP growth under the scenario of doing little and allowing climate change to run its course may seriously underestimate the cumulative losses to GDP from drought, floods, heatwaves, fires, storm surges, extreme weather events and higher insurance premiums by 2050. By doing nothing, we would be running the serious risk, and indeed likelihood, of our economies taking a far bigger hit in the future from the effects of climate change and more frequent extreme weather events than the 'business as usual' baseline projections suggest. A recent study suggests for example, that previous economic models may have very substantially underestimated the economic costs of episodic flooding from storm surges due to higher sea levels.[32]

If the science relating to sea-level rise continues to consolidate over the next decade, as seems likely, the potential for future sea-level rises and associated storm surges is likely to have serious implications for coastal property values and insurance premiums. Properties used for loan collateral may be revalued by lenders, land taxes may become delinked from changing property values, and insurance premiums may climb across entire economies if losses in coastal areas and from extreme weather events are cross-subsidised by insurance companies from elsewhere. None of these effects are captured in the standard non-monetary economic models usually used to assess the potential costs of climate change.

A recent World Bank study of 84 developing countries showed that even a one-metre rise in sea levels would affect more than 56 million people.

In considering the economics of climate change and the possibility of a reduction in the growth of our GDPs we should consider three further issues.

First, a substantial body of research in the economic literature suggests that in the industrialised countries, 'wellbeing' or 'happiness' has actually become delinked from GDP growth. This is not the place to discuss that debate but it suggests that we should be wary of studies that simplistically equate foregone economic growth with foregone improvements in wellbeing.[33]

Second, uncertainty is poison to economies. Businesses and investors need a clear and predictable regulatory environment. A "long, loud and legal" framework to establish a carbon price signal, was one of the central recommendations of the Australian Business Roundtable on Climate Change's report *The Business Case for Early Action*.[34] Businesses know that change is necessary. What they need from governments is a clear policy framework that takes the issues seriously and provides clear signals and incentives for innovation and positive responses. Without these signals, further investment will take place in inefficient and polluting technologies.

Third, even relatively small sea-level rises will result in the displacement of tens of millions of people, associated with severe economic and social costs and a high probability of conflict. A recent World Bank study of 84 developing countries showed that even a one-metre rise in sea levels would affect more than 56 million people.[35] The poor are likely to suffer most from climate change, just as they have suffered most from the terrible droughts and famines induced by severe El Niños in the past. Africa, Bangladesh, Vietnam, China and the small island states are particularly vulnerable.[36] APEC members should take a long-term view of these issues. Much of the language in the reports concerns projections out to 2100. But human history will likely continue beyond 2100, with warming continuing and sea-levels rising, risking substantial melting from the Greenland and West Antarctic ice sheets. In a world with sea levels several metres higher than today, tens of thousands of square kilometres of the world's best agricultural land would be lost, along with the homes of hundreds of millions of people. Vast swathes of territory would be under water, including much of Bangladesh, and the great river deltas of the Mekong, Irrawaddy, Indus, Ganges, Bramaputra, Yangtze, Amazon, Nile and Mississippi.

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Such dramatic climatic changes, sea-level rises and large-scale movements of millions of people across borders are a recipe for protracted, bloody conflicts and human misery.[37] We have no moral right to pursue a path which could allow this to happen. In summary, it is reasonable to conclude that while we have a reasonable grasp of the minimum possible impacts from climate change, we have no clear idea what the maximum might be.

4. Recommendations

In view of the previous discussion and the evidence presented by the IPCC, the Make Poverty History Campaign:

1. Calls for Australia and the United States to ratify the Kyoto Protocol and to participate fully and constructively in future climate change negotiations.

2. Calls for OECD members of APEC to reduce their net greenhouse gas emissions below 1990 levels by at least 20-30% by 2020 and by at least 80% by 2050, by means of the most economically efficient and socially equitable means available.

3. Calls for developing country members of APEC to take steps to substantially reduce their net greenhouse gas emissions by 2050, recognising the serious developmental consequences of failing to do so.

4. Calls for APEC governments to send clear and unequivocal policy signals on climate change mitigation and adaptation strategies to businesses and investors to reduce uncertainty and to induce technological innovation.

5. Calls for APEC governments to implement higher mandatory energy-efficiency standards in vehicles, building design and appliances, with financial assistance to the poor to help them meet those standards.

6. Calls for APEC governments to significantly increase public research funds directed towards climate change dynamics, renewable energy technologies, carbon capture and sequestration, and energy efficiency.

7. Calls for a special international panel of expert scientists to assess the dynamics and stability of the Greenland and West Antarctic ice sheets and to incorporate those findings as soon as possible into climate models and sea-level projections.

8. Calls for significant additional increases in aid to help developing countries to adopt a clean development pathway by improving energy efficiency, adopting energy-efficient production processes, adopting renewable energy technologies, reducing deforestation and reforesting denuded areas.

9. Calls for significant additional increases in aid to help developing countries to adapt to climate change through measures such as disaster preparedness planning, and improving food and water security. Funds for adaptation to climate change should come on top of existing pledges to reach 0.7% of donors' Gross National Incomes.

5. Conclusions

Climate change represents one of the greatest challenges humanity has faced. It raises profound scientific, ethical, economic and developmental questions, which we are only beginning to appreciate. Its implications and effects may well dominate the political landscape of the 21st century and beyond. It is likely to be a time of great upheaval, in which the poor are particularly vulnerable. Only with the full support of APEC member governments, can we hope to hold back the tide.

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