Global Warming and Climate Change: The Legal, Public and Ecological Health Consequences

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A thesis submitted for the Degree of PhD

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Abstract

This thesis by publication consists of three published books: (1) (with Professor David Shearman), *Climate Change Litigation: Analysing the Law, Scientific Evidence and Impacts on the Environment, Health and Property*, (Presidian Legal Publications, Adelaide, 2006); (2) (with Professor David Shearman), *The Climate Change Challenge and the Failure of Democracy*, (Praeger, Westport, 2007) and (3) (with Professor David Shearman and Sandro Positano), *Climate Change as a Crisis in World Civilization: Why We Must Totally Transform How We Live*, (Edwin Mellen Press, Lewiston, New York, 2007) (winner of the Adele Mellen Prize for distinguished contribution to scholarship).

The works attempt to understand the human health consequences of global climate change from both a public and ecological health perspective and to address how practitioners of law and other cognitive disciplines, may collectively act to aid humanity in confronting the climate crisis. The candidate concludes that we must not only totally transform how we live, but how we think, in respond to a challenge which many authorities believe is one of the greatest threats that the human species has faced in thousands of years.

Declaration

This work contains no material which has been accepted for publication for the award of any other degree or diploma in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text.

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Statement on the Contributions of Jointly Authored Research

This submission comprises three jointly written books, as named on page iv above. *Climate Change Litigation*, *The Climate Change Challenge and the Failure of Democracy*, and *Climate Change as a Crisis in World Civilization*, have been co-written with Professor David Shearman, the applicant's supervisor and *Climate Change as a Crisis in World Civilization*, has also been co-written with Mr. Sandro Positano. The co-writers certify by their signature below that the candidate has, in the case of the books, *Climate Change Litigation* and *Climate Change as a Crisis in World Civilization*, made the majority contribution in terms of the conceptualization, documentation and realization of the works, and that in the case of the book, *The Climate Change Challenge*, this contribution has been substantial, but less than half the creative output.

The co-authors give their permission for the published books to be included in the thesis submission.

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I am grateful to a large number of scientists and scholars, who assisted me in various ways with this thesis by publication, including supervision, peer reviews and endorsements. Of course they are not responsible for the works as presented here. I thank: Dr Paul Babie, University of Adelaide; Professor Yaneer Bar-Yam, President of the New England Complex Systems Institute; Dr Catherine Bennett, Centre for Molecular, Environmental, Genetic and Analytic Epidemiology, University of Melbourne; Associate Professor Katharine Betts, Swinburne University of Technology; Associate Professor Malcolm Bond, Flinders University of South Australia; Professor Colin Butler, Australian National University; Dr Peter Christoff, University of Melbourne; Professor Charles Clement, Instito Nacional de Pesquisas da Amazonia, Brazil; Professor David Ehrenfeld, Rutgers University; Dr Ernest Healy, Monash University; Professor Ove Hoegh-Guldberg, University of Queensland; Professor Graeme Hugo, University of Adelaide; Professor Sue Koger, Willamette University; Dr R. A. D. Kooswinarsinindah, Bundung Institute of Technology, Indonesia; Dr Michael Lardelli, University of Adelaide; Dr Graham Lyons, University of Adelaide; Professor Mike MacCracken, Climate Institute, Washington DC; Professor A.J. McMichael, Australian National University; Professor Brian Moss, University of Liverpool; Professor Michael Northcott, University of Edinburgh; Dr Barrie Pittock, CSIRO Marine and Atmospheric Research, Australia; Mr. Sandro Positano, Repatriation General Hospital, Adelaide; Professor Graham Priest, University of Melbourne; Dr Haryono Tandra, Parahyangan Catholic University, Indonesia; Professor Dennis Rohatyn, University of San Diego; Professor David Shearman, University of Adelaide; Professor Nigel Stocks, University of Adelaide; Professor Max Tegmark, Massachusetts Institute of Technology; Dr Ted Trainer, University of New South Wales; Professor Sir Crispin Tickell, University of Oxford and Dr Kevin White, Australian National University.

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Contextual Statement

Aims Underpinning the Publications

This PhD thesis by publication is a study of the legal, public and ecological health consequences of global warming and global climate change. The field of public health is concerned with the nature of health threats to human society and how such threats are managed to treat and prevent disease. As such the field, broadly conceived, includes the social and psychological dimensions of human behaviour, as well as the physical.[1] The ecological health or conservation medicine paradigm has an even more broad research focus and aims to unify the disciplines of ecology and health. According to Gary M. Tabor, the ecological health paradigm represents

> an attempt to examine the world in an inclusive way. Health effects ripple throughout the web of life. Health connects all species. The interaction of species is inextricably linked to the ecological processes that governs life.[2]

The field of ecological health aims "to develop a scientific understanding of the relationship between the environmental crisis and both human and nonhuman animal health and to develop solutions to problems at the interface between environmental and health sciences."[3] This thesis attempts to understand the ecological health consequences of global climate change as part of a broader "crisis of civilization" which threatens the world as we know it.

The three books submitted for examination for the degree continue themes which the candidate has pursued over almost two decades of the examination of the ecological crisis.[4] By way of summary, the world faces a series of interacting and converging threats, including "peak oil"- the depletion of fossil fuels, emerging water and food shortages, biodiversity destruction and a rapid rate of species extinction ("the sixth extinction") [5]and many other ecological problems, most of which are made more severe and problematic by global climate change. As Nick Mabey has put it: "[t]he coming decade will see rising resource scarcity, greater environmental degradation and increasingly disruptive climate change at levels never experienced before in human history."[6] Current responses to this threat are, he shows, "slow and inadequate,"[7] a proposition also argued for by the candidate in his three submitted books. Mabey concludes that uncontrolled climate change, on a business-as-usual scenario, "will have security implications of similar magnitude to the World Wars, but which will last for centuries."[8] Severe climate change could see, he believes, Africa as a failed continent and the collapse of China, among other scenarios.

There is a growing body of scientific evidence which indicates that the threat posed to human health and welfare by global climate change is far worse than the position expressed by the Intergovernmental Panel on Climate Change (IPCC), which represents the existing scientific consensus on climate change. If this is correct – and the submitted works argue that it is – how *should* humanity deal with a challenge of such magnitude? The core thesis of the submitted works is that we need fundamentally to change both how we think and how we act if we are to survive and that it is a mistake to place all our hopes upon some technical fix to save humanity at the 11th hour. As the candidate was quoted as saying in an article in *Environmental Health Perspectives:*

> In a nutshell, each discipline and field can make a contribution. But none of them is sufficient on its own to really carry the weight. It's got to be everybody working together at both the individual and international levels to deal with it. There's no one solution.[9]

Leading climate scientist Sir Crispin Tickell, in an endorsement statement written for the candidate's most recent book, *Climate Change, The Environmental Crisis and Human Survival*[10] aptly summed up the candidate's core aim and approach:

> Understanding the extent of the damage we are doing to life on Earth as well as to our own society is spreading. But most people still carry on as they did. The first requirement is to think differently across the spectrum – from economics to philosophy – and to reformulate our behaviour in the light of it.[11]

The three submitted books articulate how we may reformulate our behaviour to deal with the climate change challenge.

The literature review for this thesis overview will comprise an update on some of the latest scientific evidence, more recent than the evidence presented in the three published books, indicating that global climate change is occurring faster than the IPCC has predicted. This is a central theme of the candidate's work, and it is important that a cogent justification of such a central proposition is presented, especially to outline the research context of the presented publications.

Literature Review

Worse than Expected: The Grim Facts and Science of Climate Change

The United Nations Secretary-General Ban Ki-Moon, in his Address to the Intergovernmental Panel on Climate Change upon release of the Fourth Assessment Synthesis Report on November 17 2007 said:

> I am humbled after seeing some of the most precious treasures of our planet being threatened by humanity's own hand…In Antarctica, the message was chillingly simple: the continent's glaciers are melting. I saw the heart-bursting beauty of ice shelves that have already started to break up…if large quantities of Antarctica's ice were to melt, sea levels could rise catastrophically. …In Punta Arenas, Chile, near the centre of the famous ozone hole in the Earth's atmosphere, children wore protective clothing against ultraviolet radiation. There are days when parents don't let them play outside, or even go to school.
>
> These scenes are as frightening as a science fiction movie. But they are even more terrifying, because they are real.[12]

Some news items, near to the release of the Fourth Assessment Report and at the time of the release, were along the lines of "Greenhouse gas levels already past 'worst-case' scenario".[13] However the IPCC process of consensus, as well the five year process, means that some of the science is already out-of-date by the publication date.[14] As well, the emphasis on consensus produces a conservative scientific summary that may exclude or downplay some extreme possibilities.[15] The IPCC chairman, Rajendra Pachauri, has said that since work was begun on the Fourth Assessment Report, scientists have recorded "much stronger trends in climate change" including recent, previously unpredicted melting of polar ice.[16] There is thus, in Pachauri's opinion, a need to start early interventions: "If there is no action before 2012, that's too late. What we do in the next two to three years will determine our future. This is a defining moment".[17]

A brief outline of some of the main conclusions reached in the IPCC Fourth Assessment Report will be made before turning to consider more recent evidence indicating that global climate change matters are worse than depicted in the Fourth Assessment Report.

According to the IPCC, it is extremely likely, with a confidence range of 95 percent or higher, "that humans have exerted a substantial warming influence on climate."[18] "Radiative forcing" is defined in the IPCC Report as "the change in net (down minus up) irradiance (solar plus long wave; in Wm^{-2}) at the tropopause after allowing for stratospheric temperatures to readjust to radiative equilibrium, but with surface and tropospheric temperatures and state held fixed at the unperturbed values".[19] What this essentially means is that radiative forcing is a measure of the rate of change of energy per unit area of the Earth, in units of watts per square metre, relative to the upper part of the atmosphere. Radiative forcing examines how the Earth-atmosphere energy balance changes when changes occur to the climate system,[20]and thus measures quantitative differences in the strengths of the human and natural courses of climate change. According to the IPCC the anthropogenic radiative forcing is at least five times greater than changes due to solar irradiance, so that between 1950 and 2005, "it is *exceptionally unlikely* [meaning with a confidence range of less than 1 percent] that the combined natural [radiative forcing] (solar irradiance plus volcanic aerosol) has had a warming influence comparable to that of the combined anthropogenic [radiative forcing]".[21] There is a very high confidence (meaning greater than 90 percent probability) that since 1750 human activities have had a net positive radiative forcing effect of + 1.6 (+ 0.6 +/- 2.4) watts per square meter.[22]

It is very likely, with a greater than 90 percent probability, that the observed increases in the global average temperature since 1950 are due to increases in human-caused greenhouse gas concentrations. Since 1950 solar and volcanic activity would have produced global cooling rather than warming and it is likely (meaning greater than 66 percent probability) that greenhouse gas emissions would have caused even more warming without the offsetting effects of solar and volcanic activity.[23]

Since pre-industrial times global greenhouse emissions from human activities have increased dramatically.[24] Of the anthropogenically produced greenhouse gases, carbon dioxide is the most important and the annual global emissions of carbon dioxide have risen around 80 percent between 1970 and 2004, from 21 to 38 gigatonnes (Gt), being 77 percent of the total 2004 anthropogenic greenhouse gas emissions.[25] Over the past 250 years, based upon ice core analysis and other methods, it has been determined that carbon dioxide has increased by about 100 ppm from 275-285 ppm in the pre-industrial era to 379 ppm in 2005.[26] There has been an increase in the absolute rate of increase of atmospheric carbon dioxide. It took 200 years for the first 50 ppm increase above pre-industrial levels to be reached in the 1970's. However the next 50 ppm increase occurred in around 30 years, and from 1995 to 2005 an increase of 19 ppm occurred.[27] The human activities producing this rapid growth in carbon dioxide concentration include, emissions from combustion of fossil fuels, gas flaring, cement production, land use changes (especially deforestation) and biomass burning.[28]

Equilibrium climate sensitivity, equilibrium global average warming for a doubling of atmospheric carbon dioxide, is likely (meaning, with a greater than 66 percent probability) to be in the range of 2 C to 4 C, with the most likely figure being 3 C. It is very likely (meaning greater than 90 percent probability) to be greater than 1.5 C. The IPCC observes that for "fundamental physical reasons, as well as data limitations, values substantially higher than 4.5 C still cannot be excluded, but agreement with observations and proxy data is generally worse for those high values than for values in the 2 C to 4.5 C range." [29]

This, however, needs qualification. The IPCC uses what they call SRES scenarios arising from the IPCC Special Report on Emission Scenarios.[30] These are described as follows:

> The A1 storyline assumes a world of very rapid economic growth, a global population that peaks in mid-century and rapid introduction of new and more efficient technologies. A1 is divided into three groups that describe alternative directions of technological change: fossil intensive (A1 FI), non-fossil energy resources (A1 H) and a balance across all sources (A1 B). B1 describes a convergent world with the same global population as A1 but with more rapid changes in economic structures toward a service and information economy. B2 describes a world with intermediate population and economic growth, emphasizing local solutions to economic, social, and environmental sustainability. A2 describes a very heterogeneous world with high population growth, slow economic development and

slow technological change. No likelihood has been attached to any of the SRES scenarios.[31]

On this basis the projected global average surface warming at the end of the 21st century can be summarized as depicted in Table 1.1, with the temperature change in degrees C at 2090-2099 being relative to 1980-1999.

Table 1.1[32]

Scenario	Best Estimate	Likely Range
Constant year 2000 concentrations	0.6	0.3 - 0.9
Bl scenario	1.8	1.1 - 2.9
A1 T scenario	2.4	1.4 - 3.8
B2 scenario	2.4	1.4 - 3.8
A1 B scenario	2.8	1.7 - 4.4
A2 scenario	3.4	2.0 - 5.4
A1 FI scenario	4.0	2.4 - 6.4

As can be seen from Table 1.1 on a business-as-usual scenario of very rapid economic growth with an intensive use of fossil fuels – a scenario which represents essentially the economic world of today - the global temperature rise could be as bad as 6.4 C, with the best estimate being a 4 C rise.[33] This is a far different world from the one of small temperature increases envisaged by the climate change critic Bjorn Lomborg in *Cool It*.[34] Lomborg is mentioned here, and his work is subjected to a critique in the published submitted works, because he is perhaps the best known climate change skeptic in the public arena and his works have been best-sellers. He serves as an example of the amalgamation of all the points that have been made by intellectuals denying the existence or the extent of global climate change.

Lomborg cites the IPCC 2007 Report as estimating that sea levels will rise about a foot or 30 centimetres over the 21st century.[35] He says that since 1860 the world has experienced a sea-level rise of about that amount without "major disruptions."[36] The IPCC says that sea levels will rise by the end of the 21st century under the SRES B1 scenario by 0.18 to 0.38 metres; on B2 by 0.20 to 0.43 metres; A1 B by 0.21 to 0.48 metres; A1 T by 0.20 to 0.45 metres; A2 by 0.23 to 0.51 meters and

A1 FI by 0.26 to 0.59 metres.[37] The oceans have warmed: over the period of 1961-2003 the global ocean temperature has risen by 0.10 C from the surface to a depth of 700 meters and the global ocean heat content has increased at the rate equivalent to the energy absorption of 0.21 ± 0.04 watts per square meter averaged over the surface of the Earth.[38]

Equally as important as the physical changes resulting from ocean warming are changes in ocean biogeochemistry. Rises in atmospheric carbon dioxide concentrations increase the acidification of the surface ocean. According to the IPCC, multi-model projections based on various SRES scenarios see a reduction in ocean PH (acidity or alkalinity) of 0.14-0.35 units in the 21st century. There has already been a decrease from the pre-industrial era of 0.1 units. The increase in the acidity of the oceans is occurring 100 times faster than in recent geological history. Moving away from the IPCC report to more recent peer-reviewed papers, Hoegh-Guldberg (et.al.)[39] claim that if global mean temperatures rise by at least 2 C over the 21st century and atmospheric carbon dioxide concentration exceeds 500 ppm, "global warming and ocean acidification will compromise carbonate accretion, with corals becoming increasingly rare on reef systems. The result will be less diverse reef communities and carbonate reef structures that fail to be maintained. Climate change also exacerbates local stresses from declining water quality and overexploitation of key species, driving reefs increasingly toward the tipping point for functional collapse."[40] Hoegh-Guldberg (et.al.) used the lower range of the IPCC scenarios "yet still envisage serious if not devastating ramifications for coral reefs…global temperatures of 3 to 6 C defy consideration as credible alternatives." [41] Rising carbon dioxide levels could endanger a third of all marine life.[42] The loss of marine life and the decline of global fisheries will impact upon the food resources of millions of people.

Let us, however, return for the moment to Lomborg's claim that the IPCC 2007 Report that sea levels will rise about 30 centimeters over the 21st century, is "good news." In a sense, this is true compared to other predictions which we will examine shortly. However, even given these sea level rises, at least 21 of the world's mega-cities will face threats, as about one-tenth of the world's population live in low-lying areas that would be vulnerable to such risks.[43] Bangkok already has a major problem of rising sea levels due to sinking land alone, and the IPCC has warned that this problem, combined with rising sea levels from global warming, threaten to swamp Bangkok.[44] That humanity has dealt with sea level rises of about the same amount in the past does not show, contrary to Lomborg, that future societies will be free of “major disruptions.”

There are recent papers arguing that the IPCC’s 2007 projections of a sea level rise by 2100 of 0.18 - 0.59 meters, is too conservative. For the moment, let us leave aside issues regarding observations relating to changes in snow, ice, and frozen ground. Rahmstorf (et.al.)[45] examined the most recent data for observed climate trends for carbon dioxide concentration, global mean air temperature and global sea level and concluded that the “data now available raise concerns that the climate system, in particular sea level, may be responding more quickly than climate models indicate”.[46] The observed sea level has been rising faster than the climate models predict, as based upon tide gauge data and satellite altimeter data: of about 3.3 ± 0.4 mm/year over the 1993-2006 period. The IPCC best-estimate projection is less than 2 mm/year.[47] Rahmstorf (et.al.) conclude that the previous IPCC projections “may in some respects even…underestimate the change, in particular for sea level”.[48] Rahmstorf’s own projection, based upon a “semi-empirical” relationship connecting global sea-level rise to global mean surface temperature, is a projected sea-level rise in 2100 of 0.5 to 1.4 metres above the 1990 level.[49] This projection is consistent with other work, such as a study by the Spanish Oceanographic Institute, which sees on business-as-usual scenarios a rise in the level of the Mediterranean by another half a metre in the next 50 years with “catastrophic consequences.”[50]

James Hansen and collaborators believe that “scientific reticence” is inhibiting discussion of large sea level rises of meters in the 21st century on a business-as-usual scenario.[51] Among other things, Hansen (et.al.) are concerned about positive feedback mechanisms and nonlinear effects (multiplicative, rather than additive effects), especially in relation to the survival of the world’s ice sheets. Hansen disputes the IPCC projected rates of sea level rise because “they suggest that the ice sheets can miraculously survive a [business-as-usual] climate forcing assault for a period of the order of a millennium or longer.”[52] Paleoclimatological data, in Hansen (et. al.)’s opinion, suggests that sea level rises will be much greater than the IPCC projections, and at worse, possibly in the range of meters.

The IPCC in its study of the cryosphere (snow, river and lake ice, sea ice, glaciers and ice caps, ice shelves and sheets and frozen ground) have concluded that the total contribution made by the cryosphere to sea level change was in the range of

0.2 to 1.2 mm per year between 1961 and 2003 and 0.8 to 1.6 mm per year between 1993 to 2003. This was from Greenland Ice Sheet and Antarctic Ice Sheet melts, as well as losses from glaciers.[53] Since 1978 there has been a 2.7 ± 0.6 percent per decade decline in the annual mean Arctic sea ice extent.[54] By way of summary:

> [The] ice sheets in Greenland and Antarctica have *very likely* been contributing to sea level rise over 1993 to 2003. Thickening in central regions of Greenland has been more than offset by increased melting near the coast. Flow speed has increased for some Greenland and Antarctic outlet glaciers, which drain ice from the interior. The corresponding increased ice sheet mass loss, has often followed thinning, reduction or loss of ice shelves or loss of floating glacier tongues. Assessment of the data, and techniques suggests a mass balance of the Greenland Ice Sheet of between +25 and – 60 Gt yr^{-1} (-0.07 to 0.17 mm yr^{-1} SLE) from 1961 to 2003 and -50 to -100 Gt yr^{-1} (-0.14 to 0.28 mm yr^{-1} SLE) from 1993 to 2003, with even larger losses in 2005. Estimates for the overall mass balance of the Antarctic Ice Sheet range from + 100 to -200 Gt yr^{-1} (-0.28 to 0.55 mm yr^{-1} SLE) from 1961 to 2003, and + 50 to -200 Gt yr^{-1} (-0.14 to 0.55 mm yr^{-1} SLE) from 1993 to 2003. The recent changes in the ice flow are *likely* to be sufficient to explain much or all of the estimated Antarctic mass imbalance, with changes in ice flow, snowfall and melt water runoff sufficient to explain the mass imbalance of Greenland.[55]

There is a body of evidence of peer-reviewed scientific papers and reports tending toward the James Hanson-position rather than the more conservative IPCC position. For example, the United Nations Environment Programme, *Global Outlook for Ice and Snow,* says that the cryosphere is melting faster than previously predicted.[56] Satellite and tide gauge data indicates that the rate of sea level rise for the 20th Century was 1.7 mm per year, but the rate of sea level rise is now 3.1 mm per year.[57] About a third of the rise in sea level, according to the report, is due to the melting of the cryosphere and the rest is due to thermal expansion of the oceans.[58] The report notes that the "contribution of meltwater to sea level rise can be expected to continue and accelerate as more land ice melts."[59] For example, there has been a decline in the mean monthly snow-cover extent in the Northern Hemisphere at a rate of 1.3 percent per decade over the last four decades.[60] By the end of the 21st century the mid-latitudes will also experience a major reduction in snow cover. Snow cover has a high reflectivity; decreases in snow cover will change the reflectivity of land surfaces and provide a positive feedback mechanism with respect to global warming.[61] Apart from that, snow in mountainous regions supplies water to about one-sixth of the world's population and the continuity of these supplies will be threatened by such meltdowns.[62]

Glaciers are melting today at a faster than expected rate. According to Professor Wilfried Haeberli, Director of the World Glacier Monitoring Service, glaciers today are melting faster than at any time in the past 5,000 years.[63] The World Glacier Monitoring Service has monitored 30 glaciers for 30 years and observed in 2006 the largest net loss of ice. Even on the IPCC's mid range projection of a global temperature rise of 2 C, there will still be substantial decline in glacier ice throughout the 21st Century.[64] Bjorn Lomborg in *Cool It* says that glaciers have been receding since 1800 with some recessions due to regional shifts to drier climates rather than 20th and 21st Century climate change.[65] Mount Kilimanjaro is an example which has been losing ice since 1880 due to regional climate change.[66] That however is only one glacier, and the World Glacier Monitoring Service has monitored 30. Nevertheless, Lomborg dismisses the concerns about accelerated glacier melting, saying that it will mean a "boom now" from more water and there will be time enough in the future to worry about water storage problems. [67] The problem is not one of mere water storage, since as he admits, with continuous melting, the glaciers will run dry. The issue is about the long-term protection of water supply. Further, there is also the problem of a positive feedback mechanism operating, as mentioned above, of the change in reflectivity of the land surface from the loss of ice.

Dr John Church, head of the sea level program of the Antarctic Climate and Ecosystem Co-operative Research Centre, Australia, is particularly concerned about the Greenland Ice Sheet because an increase in global average temperature of 3 C would push the ice shelf to a tipping point where melting exceeds precipitation and the rapid meltdown of the sheet would be inevitable.[68] As an example of one of these unanticipated surprises, Dorthe Dahl-Jensen, of the Niels Bohr Institute at Copenhagen University, in a study of Greenland Ice, found that there was an unexpectedly rapid change in the ice stream. Such ice moves through the bulk of the ice, like a river, and may form icebergs at the mouth, by a process called "calving." According to Dahl-Jensen, in "just two-three years the speed of a large ice stream nearly doubled. This means that we have under-estimated the rapid changes that may ensue from the amounts of ice leaving the ice each year."[69] For this reason alone, the rise of global sea levels may be faster than expected on the basis of IPCC projections.

In relation to the issue of tipping points for the Greenland Ice Sheet, Hansen sees a substantial melt occurring before a 2 C global average temperature is reached, followed then by multiple positive feedbacks and a rapid non-linear meltdown.[70]

More recently, Lenton (et.al.) have said that on a business-as-usual scenario, by contrast to the IPCC timescale of greater than 1,000 years for the collapse of the Greenland Ice Sheet, "a lower limit of 300 years is conceivable."[71] Lenton (et.al.) have identified "strong nonlinearity" in positive ice-albedo feedbacks regarding Arctic sea ice and suggest that the system may have already passed a tipping point or critical threshold beyond which it will not recover in the short geological term.[72] The decline in the sea ice acts as a positive feedback mechanism for global warming, in turn accelerating the melt rates because sea ice reflects more sunlight than the darker surface of the sea. According to a peer-reviewed report by the Climate Adaptation Science and Policy Initiative of the University of Melbourne,[73] melting sea ice in the Arctic is one piece of evidence of accelerated climate change. The decreases in Arctic sea ice have occurred faster than predicted by the climate change models. There was a new summer minimum set in 2007 and the "current summer minima are approximately 30 years ahead of a range of simulation forecasts".[74] On a "business-as-usual" scenario, an ice-free Arctic Ocean could occur as early as 2050.[75] Arctic temperatures have already been increasing at almost double the global rate and projections indicate that this warming trend will continue, perhaps at a previously unanticipated rate.[76] Recently published data from the National Snow and Ice Data Center (NSIDC) has recorded the second largest summer shrinkage of Arctic ice since satellite observations began 30 years ago, and Mark Serreze of NSIDC believes that there is a strong probability of there being no ice at all in the Arctic Ocean in summer by the year 2030 – a prediction of an ice-free ocean 20 years earlier than the prediction made by the Climate Adaptation Science and Policy Initiative.[77]

Antarctica's ice is also melting faster than previously thought. The Climate Adaptation Science and Policy Initiative of the University of Melbourne notes that the Antarctic Peninsula is one of the most rapidly warming places on Earth,[78] with a rate of warming of 0.5 C per decade, compared to the global rate of 0.2 C per decade.[79] Further, there "has been increased summer snowmelt, loss of ice shelves and retreat of marine and tidewater glacial fronts. Flow rate measurements for Antarctic Peninsula glaciers indicate accelerating trends".[80] An example of the effects of climate warming in the region is the collapse of the Larsen B ice shelf in 2002.[81] At the time of writing in October 2008, the Wilkins ice shelf is also disintegrating. This is a 16,000 square kilometer area of ice, which at present is held only by a thin six kilometer wide strip of ice.[82] An iceberg 41 kilometers long and 2.5 kilometers wide broke off the ice shelf on February 28 2008.[83] The breakup of this ice shelf will not raise sea levels as it is not connected to inland glaciers.[84] Nevertheless, a joint press release from the National Snow and Ice Data Center (NSIDC), the British Antarctic Survey (BAS) and the Earth Dynamic System Research Center at National Cheng Kung University in Taiwan said: “The Wilkins is one of a string of ice shelves that have collapsed in the West Antarctic Peninsula in the past thirty years. [Such] collapses also underscore the unprecedented warming in this region of Antarctica.”[85]

Although current climate models predict that snowfall gains in East Antarctica will counteract such losses, the Climate Adaptation Science and Policy Initiative points out that accelerated ice discharges from surface and ocean warming is likely to counteract East Antarctica’s alleged snowfall “gains” - gains which have yet to be observed.[86] Recent research by an international research team led by Eric Rignot, using radar interferometry from satellites has found that from 1992 to 2006, although East Antarctica has had a glacial loss of 4 ± 61 Gt per year, in West Antarctica the ice sheet loss has increased 59 percent in 10 years, reaching 132 ± 60 Gt per year in 2006.[87] Peninsula losses increased by 140 percent to 60 ± 46 Gt per year in 2006.[88] This is due to warming Antarctic waters melting the undersides of the ice sheets and as the sea intrudes further, more melting occurs.[89] These processes of glacier dynamics are, as a review of this research in *Science* said, “so poorly understood that the Intergovernmental Panel on Climate Change could not include them in projections of sea-level rise in its 2007 report”.[90]

Further to this, there is accumulating evidence that carbon sinks such as forests and the oceans have weakened in their absorption capacities, which along with inefficiency in fossil fuel use has led to a growth of carbon dioxide levels in the atmosphere 35 percent more quickly since the year 2000 than previously thought.[91] Canadell (et.al.), estimate that 35 ± 16 percent of the increase in the atmospheric growth rate of carbon dioxide between 1970-1999 and 2000-2006 was caused by the increase in carbon intensity of the global economy (17 ± 6%) and the decrease in efficiency of natural carbon sinks (18 ± 15%). An increase in the global economy contributed 65 ± 16 percent.[92] Schimel in a study of the latest evidence concluded that “the carbon cycle has changed faster than today’s models simulate”.[93]

A consideration of the “slow feedback” mechanisms, such as the darkening and shrinkage of ice sheets, the release of methane from melting tundra, the poleward expansion of forests and other positive feedback mechanisms suggests an increase in the risk of abrupt climate change and "surprise" scenarios.[94] James Lovelock, using a "whole earth" model, found that when CO_2 in the atmosphere exceeds 500 ppm, the global temperature abruptly rises 6 C and then stabilizes despite further increases or decreases of atmospheric carbon dioxide.[95] Other researchers have concluded that there is a 54 percent likelihood that climate sensitivity is higher than the IPCC range of 2 to 4.5 C. [96] Some researchers, such as James Hansen, believe that climate sensitivity could be greater than 6 C and as high as 10 C![97]

The Met Office Hadley Centre in the UK released a decadal climate prediction model which gave predictions for the annual global temperature to 2014. Over this 10-year period the climate warms, with 2014 being probably 0.3 C warmer than 2004, but at least half of the years after 2009 will be warmer than the warmest year currently on record.[98]

In conclusion, there is a growing body of evidence available at the time of writing which indicates that the Fourth Assessment Report of the IPCC is overly optimistic. In any case, the Report is based upon peer-reviewed papers up to about mid-2006, and at the time of writing some aspects of the Report are already out of date. This is not a criticism: it is an inevitable consequence of events in a fast-moving area of science. But it means that books such as Bjorn Lomborg's *Cool It*, based upon optimistic interpretations of low to mid-range IPCC scenarios, are also questionable. We can see this more clearly by examining the literature on climate change, human health and well-being. Lomborg believes that the negative effects of global warming are exaggerated and that global warming will have many positive impacts.[99] We will see that Lomborg is mistaken about this.

Finally, from the discussion already presented, we can conclude that there is evidence of potentially huge economic costs arising from global climate change, in excess of most economists' calculations. Water scarcity, biodiversity loss, land changes, to name but a few consequences of climate change, all have worse economic consequences than are standardly depicted by economists.

Climate Change, Human Health and Well-being

Contrary to Lomborg, there is an enormous body of reports and peer-reviewed papers indicating, when this material is read as a whole, that climate change is an urgent problem that requires immediate attention and which is already impacting upon ecological,[100] agricultural[101] and economic systems.[102] The accelerating trends in global CO_2 emissions have been concisely summarized by Raupach (et.al.) thus:

> $C0_2$ 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} for 1990-1999 to >3% y^{-1} 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. Global emissions growth since 2000 was driven by a cessation or reversal of earlier declining trends in the energy intensity of gross domestic product (GDP) (energy/GDP) and the carbon intensity of energy (emissions/energy), coupled with continuing increases in population and per-capita GDP. Nearly constant or slightly increasing trends in the carbon intensity of energy have been recently observed in both developed and developing regions. 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.[103]

Again, contrary to Lomborg, according to the CSIRO Report, *Climate Change in the Asia Pacific Region*[104] a 2-4 C rise in the global average temperature over the 21st Century could have a devastating impact in Northern Pakistan, India and West China, with US $ 7.9-15.9 billion per year in damages to water resources in Asia and the number of people experiencing growing water stress increasing by up to 137 million in Central Asia and in South Asia, by up to 924 million.[105]

A more recent report, *Up in Smoke? Asia and the Pacific,*[106] the Fifth Report from the Working Group on Climate Change and Development is largely in agreement with the earlier CSIRO report. All of Asia is likely to warm during the 21st Century with more extreme patterns of rainfall from droughts to floods from inundations. The monsoonal system, upon which Asian agricultural systems are dependent, will become “more temperamental in their strength and time of onset”.[107] This could threaten food security; in South Asia half of the population of under-5 year old children is malnourished and this group is highly vulnerable.[108] At present, infant mortality rates as high as one in six occurs.[109] The Report notes that a study by the International Rice Institute indicated that an increase of only 1 C during the rice growing season would reduce global rice yields by 10 percent.[110] The significance of this is obvious: "In a region whose population is still rising, if the ability to grow food is weakened by climate change, the health and livelihoods of millions of people will be at risk".[111] The Chinese government's National Assessment Report sees a significant impact upon Chinese agriculture on a business-as-usual scenario with the productivity of Chinese agriculture falling by 5-10 percent, at a time when surging food demands require productivity increases.[112] India could see a loss of up to 30 percent of its agricultural production due to climate change related problems.[113] These are clearly problems of enormous significance to human health and well-being - also emphasized by the *Human Development Report 2007/2008*.[114] This report sees the possible breakdown of agricultural systems in the developing world leaving up to 600 million people at risk of malnutrition, an additional 1.8 billion people facing water stress by 2080, displacement through climate change-related flooding and storm activity of up to 332 million people in coastal and other low-lying areas and an additional 400 million people at risk of malaria.[115] I will have more to say about climate change and disease below.

Developed nations such as Australia will be severely impacted upon by climate change. On October 2 2007, the CSIRO and the Australian Bureau of Meteorology released the technical report, *Climate Change in Australia*.[116] The Report predicted a hotter, drier future for Australia; by 2070 Australia will be 1-2.5 C warmer on average with a best estimate of 1.8 C. By 2070 the annual warming for a high emissions scenario, could reach 3.4 C with a range of 2.2 - 5 C.[117] There are likely to be decreases in the annual average rainfall in Southern Australia, with more frequent droughts in the south-west of the country. Under a low emission scenario, the rainfall decrease is likely to be 7.5 percent by 2070, but under a high emissions scenario it could decrease by 10 percent.[118] Other predictions, of a 40 percent drop in New South Wales rainfall by 2070, see major Australian cities such as Sydney becoming "virtually uninhabitable".[119] The UN Secretary General's Official representative in Australia, in October 2007, warned the Australian Federal government that Australia should begin preparing for "climate change refugees *within* Australia" - in particular Aborigines forced off traditional lands because of climate change.[120] If the most dire climate change predictions prove true, there could also be a mass exodus from many Australian cities.

The candidate's city of Adelaide faces a particular grim water future. The

River Murray supplies 50 percent of Adelaide's water needs, but, according to research done by Anne Jensen in the School of Earth and Environmental Sciences, the University of Adelaide, the River is in ecological crisis, receiving 80 percent less water needed to prevent salt accumulation.[121] A dramatic color photograph of a parched River Murray lagoon near Mannum was published by the Adelaide paper *The Advertiser* on March 26 2007 with the headline "It's so dry here, even the European carp [a notorious pest] are dying…"[122] Since that date a $AUS 10 billion Murray-Darling rescue plan has been launched by the Federal government with the co-operation of the states. This will be a race against time as a recent article by Palmer (et.al.) in *Frontiers in Ecology and the Environment* [123]sees the Murray River systems suffering by 2050 a further 15 percent decrease in water availability.[124] The political significance of this ecological crisis will be discussed further below.

Florida provides another example of a developed region facing extreme challenges from climate change. A Tufts University study by E. A. Stanton and F. Ackerman, *Florida and Climate Change*,[125] sees climate change costing Florida US $345 billion a year in lost economic activity by 2100 on a business-as-usual scenario, and the costs will be greater if other sectors apart from those considered (tourism revenue, increased hurricane damage, at-risk residential real estate and increased electricity costs) are included, such as agriculture, fisheries, insurances, transport and water systems.[126]

Human health and well-being are also affected by the ecological dimensions of global climate change, especially biodiversity loss.[127] For global temperatures at the end of the 21st Century greater than 4 C, 40 percent or more of global ecosystems will be affected, with major extinctions occurring across the Earth.[128] Between 3 C and 4 C, extinction of 15-40 percent of endemic species will occur, with 20-30 percent of all species becoming extinct.[129] Even at 2.5 C, 20-80 percent of the Amazon rainforest is likely to be lost.[130] Climate change is one of the major drivers affecting ecosystems and biodiversity loss, through increased rates of extinction, changes in the distribution of species, changes in reproduction timing and changes in the length of the growing season of plants.[131] For example, Australia's native species are highly vulnerable to climate change.[132] Climate change is "likely to make all of the existing threats to species worse"[133] in a country that has the "worse rate of mammal extinction in the world"[134] and which is presently "losing species at an unprecedented rate."[135] To take but one example, studies by the Australian

Greenhouse Office of the effects of climate change on three Western Australian frog species found that the climatic habitats for these frogs would completely disappear with an annual increase in temperature of only 0.5 C.[136]

Climate change also impacts upon human health, where human health is viewed in conventional medical and public health terms. The World Health Organization recognized the health significance of climate change in selecting the topic "protecting health from climate change" for World Health Day on April 7 2008.[137] The World Health Organization estimates that climate change and climate-related natural disasters accounts for over 60,000 deaths globally per year.[138] Along with injury and death from fire, floods and storms, climate change affects human health through effects on food security and safety, vector-borne, rodent-borne and other infectious diseases, thermal stress and psychiatric illnesses among other variables.[139]

Lomborg believes that among the positive benefits of global warming is that heat deaths will not outweigh deaths from the cold.[140] He accepts the IPCC claim that there will be an increase in heat waves and a decrease in cold spells.[141] Lomborg also accepts that there will be an increase in heat-caused deaths in the future.[142] He claims however that "cold spells will decrease just as much as heat waves increase".[143] For example, to cite a paper more recently published than Lomborg's *Cool It*, Thacker (et.al.) conducted an analysis of the National Center for Health Statistics' Compressed Mortality File, which showed that in the United States between 1979 and 2004, there were 10,827 cold-related deaths and 5,279 heat related deaths of the 21,491 deaths caused by natural events.[144] However in Moscow, between 2000 and 2006, mortality during heat waves was greater than mortality during cold spells.[145] Any such statistics require interpretation before they can be used to support the inferences which Lomborg makes. One needs to assess admissions to hospitals during heat waves and examine the excess over the expected deaths, as those with concomitant disease die first.

The summer of 2003 in Europe is thought to be the hottest summer since AD 1500.[146] In France alone, the August 2003 heat wave resulted in almost 15,000 excess deaths, particularly of the elderly.[147] The total number of lives lost in five European countries is estimated to be between 22,000 and 35,000.[148] The Center for Health and Global Environment, Harvard Medical School, analyzed analogs for the 2003 heat wave for five US cities: Detroit, New York, Philadelphia, St. Louis and Washington

DC. Although Bjorn Lomborg believes that much heat-stress can be dealt with by air conditioning,[149] this research team found that a heat wave of similar magnitude to the European heat wave of 2003 would overload the power grid as US electricity grids are inadequate to absorb the additional loads: "Brownouts and blackouts would further exacerbate the health impacts of heat waves, affecting air conditioning and treatment facilities".[150] Here are the key projections from the US analog studies:

> • Summer frequencies of the unhealthy, offensive air masses ranged from almost 200% to over 400 % above average during the analog summer in the five cities. Frequencies also exceeded the hottest summer over the past 59 years by a significant margin.
> • Consecutive days of unprecedented length with unhealthy air masses were a hallmark of the analog heat wave, and the strings of days occurred on two different occasions during the summer.
> • All-time records for maximum and high minimum temperature were broken in all cities, and, in some locales, there were consecutive days breaking all-time records.
> • Excess deaths (which are assumed to be heat attributed) were very high for the analog summer, with an estimated total across all locations that was more than five times the average. New York's total alone exceeded the national summer average for heat related deaths.
> • New York and St. Louis had the highest death rates for the analog summer due to the many high-rises and brick row-homes with black tar roofs that absorb a lot of heat.[151]

Martens in 1998 answered the question: "What is the annual balance between a change in moderate cold and warmth-related deaths due to global climate change, in different geographical and population settings?" after conducting a meta-analysis of the existing literature, by saying that global climate change will lead to a reduction in mortality rates due to decreasing winter mortality.[152] However the IPCC Fourth Assessment Report, Working Group II, while recognizing that global climate change would result in fewer cold-related deaths said, "it is expected that these will be outweighed by the negative effects of rising temperatures worldwide, especially in developing countries".[153] In particular, although cold-related mortality has declined in some regions such as Europe since the 1950's, this reduction in winter mortality has been due to improvements in health and better home heating, rather than due to a decrease in cold days and nights.[154]

This section has given a very brief literature overview of only some of the risks to human health and well-being that global climate change presents. In particular, rather than addressing more orthodox health issues such as changes in distribution of diseases such as malaria, in the context of the previous discussion in the outline, I have looked at the ecological threats to human health. Recently McMichael (et.al.) have concluded that:

> [A] larger scale, less reliable, and potentially irreversible category of environmental health hazard is emerging. Human pressures on the natural environment, reflecting global population growth and intensified economic activities, are now so great that many of the world's biophysical and ecological systems are being impaired. Examples of these global environmental changes include climate change, freshwater shortages, loss of biodiversity (with consequent changes to functioning of ecosystems), and the exhaustion of fisheries. These changes are unprecedented in scale, and the resultant risks to population health need urgent response by health professionals and the health sector at large.[155]

I would go further and state that these issues should be of concern to all "thinking people," especially intellectuals, environmentalists and public policy makers. That is the urgent research context of the present thesis.

Why Technology Will Not Save Us

Many believe that renewable energy and clean technologies will fuel the modern global consumer society and solve the problem of the climate crisis in the bargain. The candidate's published works set out to challenge the optimism that human ingenuity and technology alone will be sufficient to solve the climate crisis. There are challenging arguments in the literature indicating that this optimism is misplaced. Of course human ingenuity in the area of energy technology should not be minimized; there is even a way of generating electricity from water squeezed down thin glass tubes.[156] Nevertheless, the energy challenge posed by the combination of peak oil, global climate change, and the expanding global economy is: how can economic trauma or collapse be averted until renewable energy can fuel the global consumer society? Jeremy Leggett in *The Empty Tank* concludes that the:

> Shortfall between current expectations of oil supply and actual availability will be such that neither gas, nor renewables, nor liquids from gas and coal, nor nuclear - nor any combination thereof - will be able to plug the gap in time to head off economic trauma as a result of the oil topping point.[157]

In Leggett's opinion economic collapse will follow. Here is his vision in more detail:

> The price of houses will collapse. Stock markets will crash. Within a short period, human wealth - little more than a pile of paper at the best of times, even with confidence about the future high among traders - will shrivel. The inescapable consequences of the crisis will then roll out in slow motion. Companies will go bankrupt by the hundreds and then thousands. Workers will fall into unemployment by the hundreds of thousands and then millions. Once affluent cities with street cafes will have queues at soup kitchens and armies of beggars on the streets.[158]

If this vision becomes our future reality, then talk of a "postnatural politics" and postmaterial values will be passé. Hoffert (et.al.) examined technologies that could contribute toward climate stabilization including energy efficiency improvements, hydrogen production, storage and transport, geoengineering and superconducting global electricity grid, and concluded that all "of these approaches currently have severe deficiencies that limit their ability to stabilize global climate".[159]

For example, consider the case of biofuels. Previous studies have found that substituting biofuels for gasoline reduced greenhouse gas emissions because of the sequestration of carbon that occurs from growing the feedstock. Searchinger (et.al.)[160] examined the carbon emissions that occurred as farmers converted forests and grasslands to biofuel crops. On the basis of a worldwide agricultural model they found "that corn-based ethanol, instead of producing a 20% saving, nearly doubles greenhouse emissions over 30 years and increases greenhouse gases for 167 years".[161] To produce biofuels existing forest and grasslands must be cleared, which releases carbon into the atmosphere as well as foregoing the carbon these mature plants sequestrate.

Further to this, diversions of lands to biofuels have already led to an increase in international wheat prices reaching 181 percent in the 36 months up to February 2008, with an overall increase in global food prices by 83 percent. [162] Combined with other factors - such as a rise in oil and energy prices, climate conditions and drought, increased demand due to the economic boom in India and China, as well as financial speculation - food insecurity has emerged as a grave risk of the 21st Century. Rising food prices have led to a food crisis in 36 countries and food rioting has occurred in Morocco, Mexico, Uzbekistan, Yemen, Guinea, Mauritania and Senegal and other countries, not due to a Malthusian lack of food, but due rather to the inability of people to buy it. The British Government's Chief Scientific Adviser, John Beddington, said at a London sustainability conference in March 2008, that a shortage of food was a problem to rival climate change: "It's very hard to imagine how we can see the world growing enough crops to produce renewable energy and at the same time meet the enormous demand for food."[163] This is so because to deal with rising world population by 2030 will require a 50 percent increase in food production, and by 2080 there will need to be a doubling of food production.[164]

Ted Trainer in *Renewable Energy Cannot Sustain Consumer Society*[165] has presented in my opinion a compelling argument showing that renewable energy sources - wind energy, solar thermal electricity, and hydrogen and so on - are not capable of sustaining the global consumer society with its quest for unending economic growth, growing material consumption and ever-higher standards of living. It is generally assumed by environmentalists that a smooth and uneventful transition can be made from fossil fuels to renewable energy sources. However as Trainer shows, there are many limitations facing renewable energy sources, both with respect to electricity and liquid fuels. Frequently optimistic pronouncements have replaced cold hard facts as champions of a particular technology strive to get their share of relatively limited research budgets. I cannot summarize Trainer's argument in full here. However, stated briefly the key problem with renewable energy sources for electricity is their variability or intermittency. This is a major problem for wind technology and for solar, as it is not windy in regions all of the time and in most regions there may be little or an inadequate amount of solar energy in winter time. Thus renewable energy sources will need to be part of a system (wind, solar thermal with battery storage) perhaps backed up by coal/nuclear. No matter what numbers of windmills are built, there is still some chance that the supply of energy will be short of demand. All of these factors will increase the capital cost of electricity by over three times that of a coal fired station plus its fuel over a lifetime of use.[166] Photovoltaic solar electricity also faces this problem of intermittency and PV works best when it is part of a system connected to coal and/or nuclear power plants. Thus if a spectrum of renewables are to be used for electrical energy, connected to a coal or nuclear system which operates during periods when the renewable energy systems are not, we will have very expensive electricity, all in the context of an economy with growing electricity demands.[167]

Liquid fuel demands cannot be met using renewable energy resources in Trainer's assessment. To provide over 9 billion people by 2060 with the required energy from liquid fuels would require 24 billion ha of biomass plantations, but the present world's total land area is only 13 billion ha. Forest, cropland and pasture lands are presently overexploited and only total 8 billion ha.[168] Further, as we have already said, there is at present increased pressure on using land for food which stands in conflict with a drive for expanded biomass production.

Trainer argues in another paper that the issue of the use of renewable energy resource use must be viewed in the context of emissions cuts of greenhouse gases of 50-80 percent in the developed world (at least) by 2050, to about 5.2 Gt/year and near zero by 2100.[169] The expected world energy demand in 2050 will be about 1100 EJ, over double the present demand. The main energy options for meeting this are energy conservation, coal with CO_2 sequestration, nuclear and renewables. Trainer generously assumes that energy conservation and efficiency will save 25 percent, leaving 875 EJ of energy to supply. Geosequestration of CO_2 captures at best, 80-90 percent of the CO_2 produced from the burning of coal. Trainer argues that for a 90 percent capture, a global amount of 288 EJ of electricity could be generated, so geosequestration would permit 9 billion people to use electricity at a rate a little less than the present Australian per capita electricity use. However, if only 80 percent of the CO_2 generated was sequestrated, then the proportion would drop to less than half the present Australian use, which is a more realistic figure. That level would be insufficient to fuel the consumer growth society, as for example, Australia's per capita electricity consumption is likely to be twice the present amount by 2050. Further, Trainer notes that electricity amounts to only 22 percent of final energy use in Australia, and at that rate of use, the remaining 78 percent of demand for fossil fuels, such as for the transport sector, could not be met. Thus the remaining energy demand must be obtained from nuclear and renewable energy.[170]

Trainer also argues that to provide the remaining demand from nuclear sources would require an expansion of nuclear reactor capacity by about 48 times present reactor capacity, exhausting uranium resources in approximately two years, and taking the highest estimates and adding Thorium, exhaustion occurs in around 15 years.[171] However if most of the world's demand is to be met by renewables, then there are other problems. If say 700 EJ is to be met by solar and wind equally, the world's present wind capacity would need to increase by 1,750 times, which, to say the least will involve location problems. The problem of the variability of renewables, discussed in great detail by Trainer in his book, *Renewable Energy Cannot Sustain Consumer Society*, would also need to be solved, and in my opinion, Trainer has put a very convincing case that it cannot. As well, the figure of 1100 EJ is only one-fifth of the amount needed to give the projected population of nine billion people in 2050 the expected per capita energy use of a developed society such as Australia in 2050.[172] This is not to say that humanity should forget about embracing renewable energy resources; obviously renewables will "buy time," but such resources are unlikely to be able to fuel the global consumer society at the present projected growth rates.

Faced with this challenge, our leaders are likely to engage with enthusiasm, some or a number of geoengineering projects, a "Climate Change Manhattan Project".[173] At the present time, geoengineering ideas for dealing with global climate change include: painting great expanses of the Earth's surface white; creating a human-made volcano; putting into orbit space mirrors; creating vast forests of artificial trees to suck CO_2 from the air; emptying iron dust into the ocean to nurture plankton and sequester carbon dioxide; using pumps and large vertical pipes to mix the nutrient-rich waters of the lower depths with the surface water to create algal blooms to consume CO_2 through photosynthesis; and, perhaps most astonishing of all, moving the Earth's orbit 1.5 kilometers out to compensate for a doubling of CO_2.[174] Ignoring the multitude of legal, political and ethical problems associated with such proposals, it is generally recognized that given existing technologies and economics, as well as foreseeable developments, many of these projects are at best "long shots" and at worse, failures.[175]

The space mirror approach is theoretically feasible according to the US National Academy of Sciences using 55,000 orbiting mirrors, but each mirror would need to be 100 square kilometers in diameter and this is too expensive for now, unless manufactured on the moon, according to Mike MacCracken of the Washington DC Climate Institute.[176] Even if superfine reflective mesh is used, there is today a real problem of damage to such large structures by space junk and meteors.

The human-made volcano idea was put forward in 2006 by P. J. Crutzen.[177] It was proposed that sulfur particles be fired into the upper atmosphere to reflect sunlight, as has occurred with natural volcanic eruptions. This idea has a multitude of problems.[178] At best it leaves the world with high and increasing CO_2 levels which would accelerate the problem of ocean acidification.[179] Thus it would be necessary to use this technical fix along with strategies for sucking CO_2 from the atmosphere or other CO_2 sequestration strategies. But then there could be a disastrous impact on the Earth's ozone shield, and if that can be escaped, adverse regional climate change.[180] If a transition is being made to a solar energy economy, the effects of sulphur aerosols on the level of incoming solar energy also needs consideration. Finally, the sulphur-injection strategy was examined by the US Center for Atmospheric Research; it was found that it would require tens of thousands of tonnes of sulphate to be shot into the air each month.[181] Bengtsson has shown that the emission of sulphate aerosols into the atmosphere to reduce atmospheric greenhouse gas levels to tolerable levels as a geoengineering project, will have to be undertaken for a period of 500 years or more if the carbon removed from the atmosphere is dissolved in the oceans. After only a few years after ceasing to fire sulphate aerosols into the stratosphere, "the climate will move back to the state determined by the greenhouse gas concentrations as fast as the planet has warmed up after a major volcanic eruption".[182]

The main difficulty with geoengineering approaches to the climate change problem is that they are simplistic and reductionist. There is often a failure to examine the long-term and full-range of consequences which a technical fix could have in a complex nonlinear system such as the climate system.[183] There are many unknowns and a high potential for "surprise" scenarios. Producing international agreement on geoengineering programs will be enormously difficult, if not impossible. Nations, "going it alone" could produce international conflict. But beyond this, as long as there are rising human impacts upon the climate system, such technical fixes will need to continue. A symptom of the problem rather than a root cause is being addressed.

Conclusion: The Research, Overall Significance and Contribution to Knowledge

In a speech given in London on April 16 2008, Professor Sir Nicholas Stern said that the climate change situation is much worse now than it was 18 months ago: "We badly underestimated the degree of damages and the risks of climate change," he said.[184] Stern also said: "Emissions are growing much faster than we'd thought, the absorptive capacity of the planet is less than we'd thought, the risks of greenhouse gases are potentially bigger than more cautious estimates and the speed of climate change seems to be faster".[185] The evidence summarized in the research publications supports that view. This situation should be a matter of grave concern to all thinking people.

As has been said, the climate change challenge is part of a series of "converging catastrophes" or potential catastrophes that humanity faces. Together these challenges constitute a crisis of civilization, a threat to our way of life and to most things we hold dear. The published books attempt to show that climate change interacts with many of these other problems, and it may well be that the global food crisis - as exhibited through rising food prices and food riots across the world - is the first civilization-shaking tsunami that pounds on the citadel of our world. As Professor Julian Cribb of the University of Technology, Sydney has recently put it: "At the back of all this is the inconvenient truth that modern civilization is unsustainable… it relies on a continuous drawdown - sometimes amounting to total destruction - of the natural resources on which it depends for its existence."[186] Further, as I have also written, this civilization-threatening problem occurs in the context of a world which is on target to surpass nine billion people by 2050, according the United Nations population estimates and projections.[187] The consequences of this are immense, and so much so, that few academics, let alone politicians boldly confront these realities. However there are no sacred cows, including the role of the modern university: all must be subject to critical scrutiny, and the published works present a comprehensive critique of most of the literature that sees technology and continual economic growth as our saviours. The research presented here for examination needs to be viewed in the context of the alarm and urgency expressed by the scientists that have been cited in this overview. That is why the candidate has devoted considerable attention to the scientific basis of the climate crisis. The published works build upon this framework and also attempt to show the limitations of received approaches to the climate change challenge.

The book *Climate Change Litigation* was the first book in the world published on the topic of the use of litigation as a method of using the law to obtain climate justice. In Australia there is a more recent edited volume, *Climate Law in Australia*,[188]which offers a wider examination of the details of Australian climate law.[189] However, the research context of *Climate Change Litigation* was informed by the research context sketched above, which sees climate change as part of a series of converging and interacting crises, to which market solutions and technical fixes are unable to respond. For example, the book did not consider in any detail the legal mechanisms associated with the Kyoto Protocol, because as explained in the other books, the Protocol is an important symbolic expression of concern but does not effectively deal with the climate change challenge, producing “no demonstrable reductions in emissions or even in anticipated emissions growth.”[190] Thus it was argued, in the context of the short-term, law could make a contribution to helping with the climate crisis by plaintiffs who have been harmed by the effects of climate change, seeking damages and other legal remedies. As well, lawsuits would bring publicity to the issues and focus public attention upon these issues. *Climate Change Litigation* proceeded to assess the jurisprudential and scientific merits of the existing literature up to about mid-2006. The candidate wrote the legal chapters, and also researched the scientific chapters and thus acquired a good amateur scientific understanding of the field. Cases since mid-2006 have been mentioned in the later published books submitted by the candidate. Here, in the spirit of the required textual overview and conclusion the candidate will not resummarise case conclusions, but instead reflect upon the overall significance of the published book. In particular, this body of submitted work attempts to show that although legal solutions have a place and a contribution to make, the sheer magnitude of the crisis of civilization, makes a legal response limited in significance. To adequately deal with the subject matter and its problems, the candidate needed to think outside the square of the traditional legal approach to problems.

Climate Change Litigation argued that there are substantial legal and methodological problems facing plaintiffs pursuing climate change litigation actions, especially causal issues relating to proof of specific harm. However, as in tobacco litigation, it is likely that growing scientific sophistication in our understanding of the effects of climate change will overcome these barriers: science will lead and guide the law. It was also argued that climate change scepticism arguments, although important in the early days of litigation, would become less important over time. Most recent case law seems to support this conclusion, which the candidate also expressed in an interview to *The Atlantic Monthly*.[191]

At the time of writing, an interesting case is unfolding where the plaintiffs, the Native Village of Kivalina and the City of Kivalina, an Inupiat village of about 400 people living on a six-mile strip of barrier reef located between the Chukchi Sea and the Kivalina and Wulik Rivers on the Northwest coast of Alaska, are suing the "big oil" defendants including ExxonMobil, BP, Shell and others. The plaintiffs seek damages from the defendants' alleged substantial contributions to global warming; a nuisance which the plaintiffs maintain is severely harming Kivalina. As well a claim is being pressed for civil conspiracy for the defendants' alleged participation in a conspiracy to mislead the public about the dangers of global climate change, including the use of global warming sceptics, who seek to discredit the consensus view on climate change. At the time of writing, the plaintiffs have lodged a "Complaint for Damages and Demand for a Jury Trial."[192] There is little more that can be productively said here beyond noting that the mere existence of such a case, relatively early compared to the comparable litigation field of tobacco litigation, confirms the predictions made by the candidate in *Climate Change Litigation*.

Further to the above considerations, the jury in the recent UK criminal case of *R v Hewke*, at the Maidstone Crown Court, found that damage done to a coal-fired power station by six Greenpeace activists was justified. The defendants successfully argued the defence of "lawful excuse" under the *Criminal Damage Act 1971*, proposing that the damage caused to property was justified to prevent a greater damage being caused to property by the damage caused by the greenhouse gas emissions from the coal-fired power station. The act done by the "Kingsnorth Six" in 2007 involved the protesters painting Gordon Brown's name on the plant's chimney. One of the protesters, Ben Stewart said at the conclusion of the trial:

> This verdict marks a tipping point for the climate change movement. When a jury of normal people says it is legitimate for a direct action group to shut down a coal-fired power station because of the harm it does to our planet, then where does that leave government energy policy?[193]

The jury, at a minimum, at least accepted the reality of the threat of climate change and the establishment of a causal link between the harm done to property and the emissions of greenhouse gases. Recent case law thus confirms the conclusions of *Climate Change Litigation*, which have been summarized above.

Climate Change Litigation has generally been well reviewed. L. Massai in *European Environmental Law* said that the book "offers a unique overview of climate change litigation in international law."[194] An anonymous review in *E-Law* said that "this is a timely, well researched resource that will be of great value to anyone with an interest in the topic."[195] The review concluded that the book "offers an excellent introduction to the topic and is a substantial contribution in a field of growing importance."[196]C. Thomson writing in *Queensland Lawyer* also saw the book as "well researched" and thought it was refreshing that "the arguments of climate sceptics are not ignored and their arguments are acknowledged as being definite obstacles for legal challenges… [T]his book provides an interesting introduction to the issue."[197]The book has also been favourably cited in the media.[198]Criticism has largely focused upon the addition of scientific material dealing with health; A. Michaelowa reviewing the book in *Climate Policy* made such a criticism, although seeing the book as "interesting."[199] Needless to say, the candidate disagrees strongly with this because such a view underestimates the immensity of the likely future human health impacts of climate change.

The Climate Change Challenge and the Failure of Democracy and *Climate Change as a Crisis in World Civilization* expanded the research focus beyond conventional legal analysis. *The Climate Change Challenge* looks at the major limitations that liberal democratic systems have in dealing with the environmental crisis, and puts the case that democracy as such will not save the planet. We recognize that authoritarian systems, such as the former USSR, have had terrible environmental records, but argue that such systems have been committed to unending economic growth as a social ideal. The crisis of authoritarian countries has been a product largely of the socialist acceptance of the idea that there are no limits to growth and that a communist world can be built on Earth. Unlike other environmentalist critics of democracy,[200] we support a form of crisis management by experts in the future if human society cannot make the democratic transition to an ecologically sustainable society: that is, when the choice is between freedom and survival. We argue that for a variety of reasons, that this is the most likely scenario if business continues as usual.

In brief, we argue that the sociobiological evidence indicates that hierarchies are intrinsic to human societies, making the long-term survival of democracy problematic, especially in a world of crisis.[201] Further, the difficulties in acting posed by the environmental crisis are particularly difficult for any political system to resolve, especially democratic ones.[202] We do not feel convinced by the reasoning of the champions of liberal democracy, such as Barry Holden in *Democracy and Global*

Warming[203] who argues that “it is *only* democracy that can overcome people’s initial unreadiness to support tough policies.”[204] On the contrary, we argue that it is very difficult to get people conditioned by consumerism to accept tough policies. As well as this, due to the existence of conflicting interests of various sectional groups, tough decision are very difficult for politicians to make in a liberal democracy. Thus, for example, the Lower River Murray faces ecological collapse at the time of writing (October, 2008) according to an unpublished report prepared by the South Australian Murray-Darling Basin Natural Resource Management Board,[205] so that there is a need to divert more water to the “lower lakes” of the River Murray to avoid irreversible degradation. However, according to the vested interest of agriculturalists, this would destroy farm production worth over AUS $ 1 billion.[206]Consequently some have concluded that the “political system had failed to deliver,” and that there needs to be declared a “state of emergency.”[207] *The Climate Change Challenge and the Failure of Democracy* outlines other examples of such failures of the political system. The defects seem built-in and irreparable, at least not without radical changes to the economic system. We hope that such changes can be made, so that democracy can be saved, and outline these reforms in chapter 10 of the book. However, the candidate is not optimistic that there is time for the implementation of these reforms or the political will to push them forward.

Is there no hope then? Is the end nigh? The most important work submitted here, *Climate Change as a Crisis in World Civilization* confronts this problem of not only political failure, but intellectual failure, to confront the crisis of civilization. This book, which was winner of the Adele Mellen Prize for distinguished contribution to scholarship, looks beyond law, technology and economics, to examine the theological, ethical and philosophical roots of our plight and explores what may be done to save human civilization. The core argument is also elaborated upon in the candidate’s forthcoming book, *Climate Change, The Environmental Crisis and Human Survival*. The thesis of both books is clearly summarised by Professor Michael Northcott, author of *A Moral Climate: The Ethics of Global Warming*[208] in an endorsement of the candidate’s latest book:

> The authors of this lucid and hard hitting book argue that climate change is part of a larger and systematic ecological disconnect between modern consumer society and the earth system. They call for a radical change in the habits of thought AND in the everyday

> practices that have accompanied the rise of the consumer society in the last fifty years. If we were to listen and respond to their arguments it is just possible that we might avoid the ecological collapse of our industrial civilization across the world.[209]

Sir Crispin Tickell said in endorsement of *Climate Change as a Crisis in World Civilization*:

> This is a thorough and scholarly approach to the most alarming problem of our time. The implications reach far beyond necessary changes in energy policy and new applications of technology, and reach toward the future of our society and civilization: how we think, how we behave, how we even survive the impact of our small animal species on the earth's life system of which we are a tiny but immodest part.[210]

Marine scientist professor Ove Hoegh-Guldberg, of the University of Queensland, also said in endorsement of the candidate's work, to break free from our "current inept pathway to almost certain catastrophe" we need to place "global society on the equivalent of a war footing."[211] Societies need to be moving away from consumer societies, based upon a creed of unending economic growth and satisfaction from consumerism, to embrace sustainable conserver societies which are not based on unlimited economic growth. The transformation of an entire civilization in a short space of time is an enormous challenge, as great as any faced by the human species. Yet the intellectual community, as represented by the modern university is not treating the ecological crisis as the global emergency which it is.

Even from the material outlined in this report, the ordinary reasonable person would surely be concerned about the plight of humanity. If leading thinkers are suggesting that economic and ecological collapse may be looming, a sane response should be to take preventative action. At the very least universities should be directing their research and teaching capacities to dealing with the crisis of civilization. *Climate Change as a Crisis in World Civilization* argues that this is not occurring due to the corporatisation of the university and its abandonment of the liberal ideal of the university as a place of freethinking and social criticism. *The Climate Change Challenge and the Failure of Democracy* and *Climate Change as a Crisis in World Civilization* present, above all else, a stinging critique of the failure of the universities and intellectuals, particularly in the social sciences, to rise to the challenge of our times. *Climate Change, the Environmental Crisis and Human Survival* continues this critique, especially criticising the discipline of philosophy for failing to continue its Socratic quest of offering a critique of the Establishment, rather than being exclusively concerned to be an underlabourer to the physical sciences.

Why, in conclusion, should this body of work be considered for a PhD in law, apart from presenting the first book in the world published on the topic of climate change litigation? Law, it seems, is a discipline which is not unsympathetic to the holistic methodology employed here. Even a brief consideration of leading legal journals will reveal that legal articles essentially pursue the argument where it leads even if scientific technicalities need to be addressed. Legal researchers are also unafraid of questioning expert opinion, and this is a major skill litigators seek. Unlike contemporary philosophy, legal researchers are interested in engaging in the on-going public policy issues of the times. Further, and most importantly, legal training encourages a dialectical and critical-argumentative approach to subject matters. That above all else, makes this body of work a contribution to law as a discipline. The field of climate change law, especially climate change litigation, is also relatively new and in new legal fields it is appropriate for the foundational researchers to examine the philosophical and empirical parameters of the field.

The three books outline the arguments of the field and subject them to a searching evaluation in a foundational way which does not seem to be practiced in the sciences. The evaluation of the books by peer reviewers and published reviews indicate that the works have already made a contribution to the climate change debate.

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>
> Poorer countries with predominantly rural economies and low levels of agricultural diversification will be at most risk. They have little

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This thesis by publication consists of three published books:

(1) Smith, J. & Shearman, D. 2006, *Climate Change Litigation: Analysing the Law, Scientific Evidence and Impacts on the Environment, Health and Property*, Presidian Legal Publications, Adelaide.

(2) Shearman, D. & Smith, J. 2007 *The Climate Change Challenge and the Failure of Democracy*, Praeger, Westport.

(3) Smith, J., Shearman, D. & Positano, S. 2007, *Climate Change as a Crisis in World Civilization: Why We Must Totally Transform How We Live*, Edwin Mellen Press, Lewiston, New York.

NOTE:
These books are held with the print copy of the thesis which is held in the University of Adelaide Library.