

Garnaut Climate Change Review

Climate change and security: managing the risk

Prepared by

Professor Alan Dupont

Contributors: Jonathan Lusthaus, Thomas Phipps, Professor Andy Pitman, Professor Rosemary Rayfuse, Dr Mark Thomson, Dr Graeme Pearman

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1 Introduction

As the scientific evidence that the Earth is heating up becomes more compelling, climate change is metamorphosing from an environmental concern to a core issue for national and international security. This paper identifies the security consequences for Australia of the climate change future we can reasonably anticipate. It does this by exploring the potential geo-political and strategic fallout for our Asia-Pacific neighbourhood, which encompasses more than half the world's population and provides the lion's share of Australia's export income. The region is also home to three of the world's largest economies (Japan, China and India), its largest Muslim state (Indonesia) and a number of small, Pacific Island states which are particularly susceptible to climate change.

Australia is better equipped than most nations to meet the challenge of climate change because of our high per capita income, advanced scientific and technological knowledge, low population densities and abundant natural resources. But most of our neighbours are more vulnerable. With few exceptions, they are still developing states with far less capacity to mitigate or adapt to climate change. As the pace of our integration with the region accelerates, any climate-induced political, social or environmental disturbances will be of considerable concern to Australia. This is because we cannot quarantine ourselves from the negative impacts of these events; especially if food production is disrupted, fresh water becomes scarce, energy anxieties worsen, diseases spread, natural disasters increase and large numbers of climate refugees result.¹ The scientific evidence to date suggests that all of these outcomes are likely, although the seriousness of their impacts will be determined by the extent, pattern and rate of temperature increases. Individually or collectively, these climate change outcomes could destabilise nations internally, aggravate tensions between states and jeopardise the lives and wellbeing of millions of people.

Box 1 Key messages

Weather extremes and greater fluctuations in rainfall and temperatures have the capacity to refashion the Asia-Pacific's productive landscape and exacerbate food, water and energy scarcities in a relatively short time span.

Climate change will contribute to destabilising, population movements in Asia and the Pacific. Most of these flows are likely to be internal, but the ripple effects will be felt beyond the borders of the states most affected, requiring cooperative regional solutions and Australian leadership.

The need to reduce greenhouse gas emissions, requiring a more rapid transition away from our dependence on fossil fuels, could place added pressure on an already tight energy market and heighten anxieties about energy security.

More extreme weather patterns would result in greater death and destruction from natural disasters adding to the burden on poorer countries and stretching the resources and coping ability of even the most developed nations.

Extreme weather events and climate-related disasters will trigger short-term disease spikes and also have more enduring consequences.

The cumulative impact of rising temperatures, rising sea levels and more mega droughts on agriculture, fresh water and energy could threaten the security of Australia's neighbours by reducing their carrying capacity below a minimum threshold.

While Australia may be better positioned to manage the consequences of climate change, we cannot be inoculated against its destabilising effects.

Should climate change coincide with other transnational challenges to security, such as terrorism or pandemic diseases, or add to pre-existing ethnic and social tensions, the impact will be magnified. State collapse and destabilising internal conflicts are more likely outcomes than inter-state wars.

Far from exaggerating the scale of climate change it is possible that scientists may have underestimated the threat. The most likely tipping point would be an accelerating reduction of land-based glaciers and the polar ice which could dramatically increase sea levels and reduce river flows.

Prudence and sensible risk management suggest that Australia's strategic planners ought to include worse case climate change scenarios in their contingency planning as they do for terrorism, infectious diseases and conventional military challenges to national security.

Since unmitigated climate change could pose a major challenge to the survival and stability of many nation states, judgements about political and strategic risk, as well as economic cost, are necessary. Probability and impact are the two main factors in assessing political and strategic risk. A high probability event may have little strategic significance because its impact is either localised or of marginal concern at the national or international level. However, significant climate change is likely to be a high probability/high impact event. The central problem is the rate at which temperatures are increasing rather than the absolute size of differential warming. Spread over several centuries, or a millennium, temperature rises of several degrees could probably be managed without political instability or major threats to commerce, agriculture and infrastructure. Compressed within the space of a few decades or a single century, global warming will present far more daunting challenges for human and biological adaptation.

Determining what constitutes 'dangerous' climate change is not easy because of the number of interconnected variables, which makes it difficult to quantify precisely the security implications. These variables include the future rate of temperature increases, sea level rise and other climate drivers; the vulnerability and resilience of individual countries, including their level of economic development; the effectiveness of adaptation and mitigation strategies; the degree of government intervention; and the pace of technological advances. Perceptions of what constitutes an acceptable risk depend on location, coping capacity and who is making the assessment. Residents of Pacific Island nations, or of Bangladesh, may see things quite differently from people living in inland Australia because of the far greater impact of sea level rise on coastal and island communities, as well as the limited capacity of less developed countries to respond.²

Another variable is the complex and highly interactive nature of the subcomponents of the earth's climate system, which complicates assessments of climate change impacts. Nevertheless, scientists have made great progress in measuring the physical characteristics of the climate and its variations, allowing the building of sophisticated computer models that integrate this knowledge into a single description of the climate system. These models have advanced significantly in the past decade due to an improved understanding of our climate and better use of observations of the real system to validate the performance of the models. New developments in computer technology allow models to more frequently and accurately represent the complexity of the atmosphere and oceans across the globe.

As a result, climatologists now have far greater confidence in their ability to understand the magnitude and nature of future climate change for a given change in atmospheric greenhouse gases. However, while climate scientists can tell us a great deal about the systemic changes in prospect, our understanding of how climate change will impact at the sub-regional or national level is far from complete. Most of the available scientific data relates to anticipated global increases in greenhouse gases, average temperatures and sea level rise. But we can't yet predict with sufficient certainty to what extent the South and Southeast Asian monsoons will be affected, how much hotter Beijing might become or the decrease in the Mekong River's flow. Nonetheless, there is an emerging consensus that if global mean temperature rises can be contained to below 2.0°C above pre-industrial levels, an increase of this order can be managed without undue risk to international security, and by extension Australia's economic and trade prospects.³ Confidence in this judgement dips sharply once the rise exceeds 2.0°C. Unfortunately, it seems very likely that this de facto temperature ceiling will be breached, probably within the next two decades.

2 Food security

In assessing the security threat to Australia and the region, it is important to bear in mind the close connection between climate change and the capacity of the region to continue to provide enough food and water to sustain its rapidly growing population. As the earth heats up and sea levels rise, there will be demonstrable and largely negative consequences for food production and fresh water availability. Food is highly sensitive to the weather and water is already in short supply.⁴ Crop yield increases have begun to level off since the late 1990s and the need to achieve greenhouse gas reductions will increase energy costs, making it more difficult to maintain the per capita food yield increases of the previous century.

While the developed world may be able to navigate these newly exposed shoals with tolerable stress, nations less well endowed will struggle, and in some cases founder. In an interconnected world, the problems of neighbours can quickly become our own, as Australia's recent history attests. Over the past decade, Australia has intervened in Bougainville, the Solomon Islands and East Timor to help resolve political and humanitarian crises. As pressure on the natural resource base of Pacific Island states increases, we can expect to see climate change compounding island vulnerabilities and feeding into political and ethnic tensions, which might require an Australian response.

Climatologists originally believed that human-induced climate change would impact most seriously on temperate zones, but that view is now being revised in the face of growing evidence that the tropics will also be significantly affected.⁵ Tropical and sub-tropical regions are home to the bulk of the world's people and produce much of its food. They include all of Southeast Asia and the Southwest Pacific. Many of the people who inhabit these regions are poor and, as a consequence, they will be less able to cope with the impact of significant climatic change on their physical environment. In the tropics, changes to major weather systems such as the monsoons and the frequency and strength of El Niño events are possible, although we do not have sufficient scientific knowledge to know whether the Asian monsoon systems are likely to fail.

Regardless, we are likely to see a reduction in regional crop yields for a number of reasons. Rain will not fall evenly or consistently, and the intensity may increase leading to more flooding and soil erosion.⁶ Higher temperatures will lead to greater evaporative losses of water and thus, on balance, less available soil moisture and captured water for irrigation. Destructive storms will have a far greater human impact in the tropics if their frequency and intensity increases. Storms could become more common and more intense in the future although it is not yet clear to what extent. Sea level rises will be felt across the globe but there will be significant regional variation. In Asia and the Pacific, many millions of people are exposed to relatively high levels of risk from flooding because of the density of urban populations and the prevalence of high value agriculture in coastal regions. The vulnerability of coasts varies dramatically for a given level of rise. Small rises in mean sea level, when associated with storm surges and major coastal populations, can be devastating. But we can't yet calculate regional variations because there has been no systematic study of variations in likely sea level rise coupled with storm climatologies and storm surge probabilities.

The Consultative Group on International Agricultural Research has predicted that food productivity in Asia will decrease by as much as 20% due to climate change as the geographical boundaries of agro-ecosystems, as well as species composition and performance, will change. These forecasts are in line with Intergovernmental Panel on Climate Change (IPCC) projections showing significant reductions in crop yield (5–30% compared with 1990) affecting more than a billion Asians by 2050.⁷ Marine ecosystems, supplying protein for millions of the poor will continue to experience major migratory changes in fish stocks and mortality events in response to rising temperatures. In addition to these longer-term, more permanent shifts in seasonal climatic patterns are near-term increases in frequency and intensity of weather extremes. These are already disrupting agriculture, fisheries and the natural resource base. Poorer countries with predominantly rural economies and low levels of agricultural diversification will be at most risk. They have little flexibility to buffer potentially large shifts in their production bases. Higher worldwide food prices are likely to result—compounding bio-physical constraints on production and negatively affecting both rural and urban poor.⁸

Climate change is likely to have a detrimental effect on regional food production for four main reasons.

First, increased temperatures could accelerate grain sterility in cereal, legume root and tuber crops as well as pasture and tree species.

Tropical grain crops could decrease 5–11% by the year 2020 because some crops are already near their maximum temperature tolerance.⁹ Other models show that as temperatures rise, the average rate of agricultural production in Southeast Asia would initially increase before declining because of shorter growing seasons.¹⁰

Second, shifts in rainfall patterns could render previously productive land infertile accelerating erosion, desertification and reducing crop and livestock yields.¹¹

A reduction in water available for irrigation will have a serious effect on crop yields internationally, especially in Asia, which is more dependent on irrigation than any other region of the world for growing rice and cereals. Although less important than it once was, rice is still a vital food staple, providing 60% of the carbohydrate and second class protein consumed by Asians.¹² Irrigation accounts for about 40% of world food production, but produces 70% of China's grain harvest.¹³ If rice paddies and croplands dry out, the carrying capacity of large parts of Asia will diminish and some countries may be unable to sustain their populations without importing large quantities of food, which may be simply unaffordable for poorer nations.¹⁴ Where dryland, non-irrigated agriculture dominates, as in many parts of Australia as well as the tropics, yields can be slashed by even small changes in temperature and rainfall.¹⁵

Much of Southeast Asia's agriculture and water resources are dependent on the monsoons. These are large scale climate phenomena that vary in intensity and reliability regionally. They depend on the patterns of sea and land temperature and the contrast between large-scale ocean and land temperatures as well as larger scale atmospheric dynamics and possibly the characteristics of the land cover. To reliably project how the monsoon system will change under global warming is complex, and reliably providing the probability of a change in the intensity or occurrence of the monsoon is presently beyond the capability of the scientific community. However, there are reasonably strong reasons to suggest that the nature of the monsoon will change. Given large populations are very dependent on the monsoon, any change will expose these vulnerable populations.

Third, rising sea levels will inundate and make unusable fertile coastal land and potential changes in the strength and seasonality of ocean currents may cause fish species to migrate and disrupt breeding grounds.

Non-commercial fisheries are likely to decline as coral bleaching takes hold and the movement of deep water fish may become more unpredictable, compounding the problem of overfishing and diminishing stocks of wild fish.¹⁶ Oceans have already absorbed about half the 800 billion tonnes of carbon dioxide humans have pumped into the atmosphere since industrialisation which, over time, has increased ocean acidity and further degraded the marine bio-system.¹⁷ As carbonate ions in the seas thin because of increased acidity, tiny marine snails and krill at the bottom of the food chain that are the primary source of food for whales and fish could be decimated, possibly within decades.¹⁸ This is a particular concern for our region as more than one billion Asians are dependent on fish for their primary source of protein. The Pacific and Southern Oceans have been aptly described as the region's 'rice bowl' for the twenty-first century.¹⁹

Fourth, it is likely (although we don't know how likely) that there will be an increase in the frequency of extreme weather events, such as cyclones, riverine flooding, drought and conceivably hail, which will disrupt agriculture and put pressure on prices.

If the gap between global supply and demand for a range of primary foods narrows, price volatility on world markets will increase. This will be exacerbated by the reduction in food stockpiles mandated by the implementation of the Uruguay Round Agreement. Furthermore, the world's food stocks are already at historical lows due to a combination of rising demand and crop substitution. Much corn is now converted to ethanol for bio-fuels, rather than being used for human consumption, and productive

farmland is being lost due to environmental degradation and urbanisation.²⁰ Without the moderating influence of substantial grain stocks, a confluence of unfavourable political and economic influences, aggravated by climate change could create local scarcities, sparking food riots and domestic unrest. If sustained, reduced crop yields could seriously undermine political stability and regional security.

3 Water scarcity

Changes in the variability and distribution of rainfall could also exacerbate fresh water scarcity in water deficient states. In a world where over 2 billion people already live in countries suffering moderate to high water stress, and half the world's population is without adequate sanitation or drinking water, relatively small shifts in rainfall patterns could push countries and whole regions into deficit, leading to a series of water crises with global implications. In Asia as a whole, per capita water availability has declined by between 40% and 65% since 1950. Although the total amount of renewable water is several times annual withdrawals, rainfall and population are spread unevenly and per capita availability therefore varies considerably—from 137,000 cubic metres in Papua New Guinea to below 3,000 cubic metres in China, South Korea and Singapore.²¹ According to the UN, by 2025 most states in the region will be facing serious water shortages unless strong action is taken.²² This steep decline is the direct result of the region's high population growth, the degradation of existing reserves of fresh water and the destruction of water tables through deforestation, urbanisation and environmentally insensitive agricultural practices.

Although it is not possible to accurately forecast detailed precipitation changes at the sub-national and local level, it is clear that countries which are already water deficient will suffer the worst shortfalls, as rainfall patterns shift and become more variable. One study concludes that about 20% of the global increase in water scarcity is directly attributable to climate change with the remaining 80% caused by growing demand.²³ By 2025, some 5 billion people are expected to suffer from serious water shortages half a billion of them due to climate change (Table 1).²⁴

Table 1 Climate change and water scarcity

Year	Total population (millions)	Population in water-stressed countries (millions)	Number of people (millions) in water-stressed countries with increase in water scarcity							
			HadCM2	HadCM3	ECHAM4	CGCM1	CSIRO	CCSR	GFDL	NCAR
2025	8055	5022	338–623	545	488	494	746	784	403	428
2050	9505	5915	2209–3195	1454	662	814	1291	1439	—	—

Source: (Arnell, N.W., Impact of climate change on global water resources: Volume 2, unmitigated emissions, Report to the Department of the Environment; Transport and the Regions, University of Southampton, Southampton, 2000).

Note: This table shows the calculated increase in water scarcity caused by climate change assuming a business as usual scenario for greenhouse gas emissions using 8 different climate models. The acronyms refer to models of different national research institutions. For example, HadCM2 refers to a specific model of the UK Meteorological Office, Hadley Centre.

In Australia, declining precipitation in water catchment areas is causing tensions between stakeholders over the appropriate use and sharing of the remaining water. Disputes over scarce water resources are likely to be far more serious and contentious in Asia, however, exacerbating existing conflicts between states over access to shared rivers and water rights and reducing water for hydro-power, transport, fishing, irrigation and water storage.

Tropical and sub-tropical areas in Asia and the Pacific will receive lower and more erratic precipitation made worse by the fact that the great Himalayan and Tibetan glaciers which flow into the Ganges, Indus, Brahmaputra, Salween, Mekong, Yangtse and Yellow rivers are receding at an average rate of 10 to 15 metres a year as their alpine climates heat up.²⁵

The melting of the Tibetan and Himalayan glaciers illustrates the complex nexus between climate change, economic security and geo-politics. Hundreds of millions of people are dependent on the flow of these rivers for most of their food and water needs, as well as transportation and energy from hydro-electricity. Initially, flows may increase, as glacial run off accelerates, causing wide spread flooding. Within a few decades, however, water levels are expected to decline, jeopardising food production and causing widespread water and power shortages with potentially adverse consequences for India, Bangladesh, China, Myanmar, Thailand, Laos, Cambodia and Vietnam.

As water availability in China has diminished because of rising demand and falling fresh water reserves, China has redoubled its efforts to redirect the southward flow of rivers from the water rich Tibetan high plateau to water deficient areas of northern China. The problem is that rivers like the Mekong, Ganges, Brahmaputra and Salween flow through multiple states. China's efforts to rectify its own emerging water and energy problems indirectly threaten the livelihoods of many millions of people in downstream, riparian states. Chinese dams on the Mekong are already reducing flows to Myanmar, Thailand, Laos, Cambodia and Vietnam. India is concerned about Chinese plans to channel the waters of the Brahmaputra to the over-used Yellow River. Should China go ahead with this ambitious plan, tensions with India and Bangladesh will almost certainly increase.²⁶ Any consequent conflicts between China and India, or other water deficient regional states, could have serious implications for Australia, disrupting trade and people flows and increasing strategic competition in Asia.

In summary, water shortages, intensified by human-induced climate change, will affect the Asia-Pacific security environment in four ways. First, they will aggravate social and political tensions adding to the internal security challenges faced by the region's developing states. Second, diminishing supplies of fresh water will adversely affect key sectors of the region's economy, especially agriculture. Today's water scarcity may become tomorrow's food shortages because of the critical role played by irrigation in Asia's food economy. Third, changes to the magnitude and/or patterns of rainfall have the potential to change the costs associated with flood and drought remediation in countries where low economic development already limits their capacity to respond to natural variations in climate. Fourth, water's salience as a driver of inter-state conflict will increase in inverse proportion to its scarcity. The region can ill afford a major drop in rainfall or a shift in distribution away from where it is most needed.

4 Infectious diseases

Climate change will have a number of serious health related impacts including illness and death directly attributable to temperature increases, extreme weather, air pollution, water diseases, vector and rodent-borne diseases and food and water shortages.²⁷ 1.7 million people die prematurely every year because they do not have access to safe drinking water and the situation will worsen if water-borne pathogens multiply as a result of rising temperatures.²⁸ A warmer marine environment will also increase the risk of human bio-toxin poisoning from fish and shell fish, as tropical bio-toxins such as ciguatera extend their range to higher latitudes.

But the greatest security risk is from infectious disease. Temperature is the key factor in the spread of some infectious diseases, especially where mosquitoes are a vector as with Ross River fever, malaria and dengue fever. As the planet heats up, mosquitos will move into previously inhospitable areas and higher altitudes, while disease transmission seasons may last longer. A study by the World Health Organisation has estimated that 154,000 deaths annually are attributable to the ancillary effects of global warming due mainly to malaria and malnutrition. This number could nearly double by 2020.²⁹ Currently, some 40% of the world's population lives in areas affected by endemic malaria and many Asia-Pacific states are seriously affected by the disease.³⁰

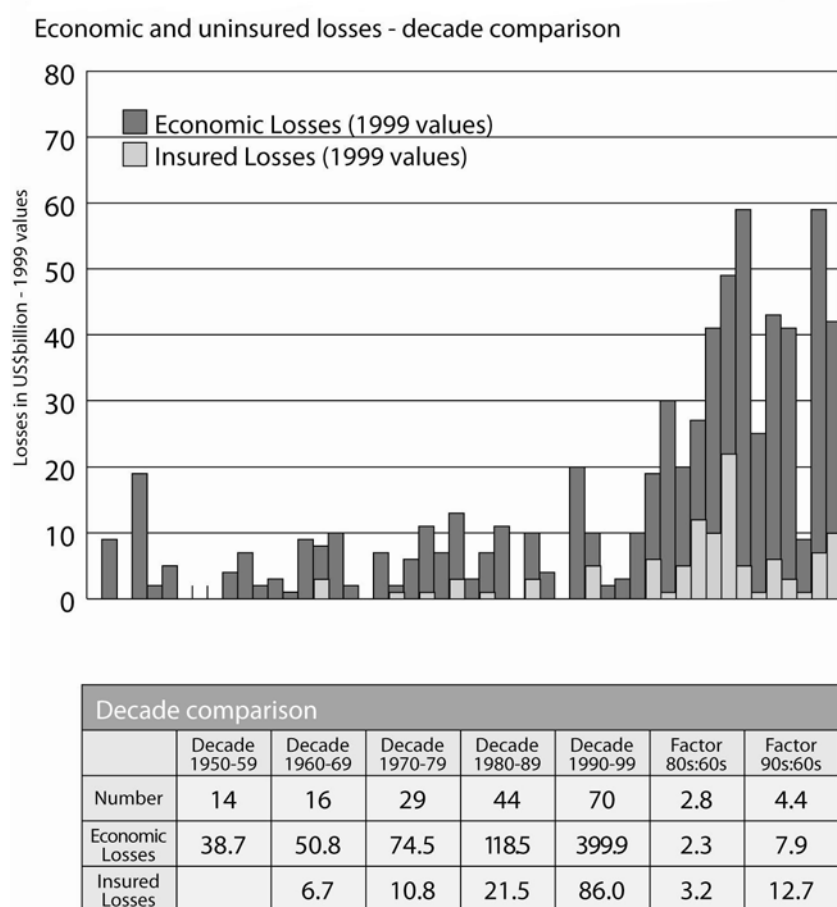
Extreme weather events and climate-related disasters could lead to short term disease spikes because of the damage to food production, population displacement and reductions in the availability of fresh water. Once again, poorer nations with limited public health services will be especially vulnerable.³¹ Health problems can quickly metamorphose into a national security crisis if sufficient numbers of people are affected and there are serious economic and social consequences, as occurred during the devastating flu pandemic of 1918–1919, which killed between 40–100 million people.³² However, it is difficult to make the case that in all cases climate change will provide a more favourable environment for the spread of infectious diseases, since transmission rates and lethality are a function of many interrelated social, environmental, demographic or political factors. They include the level of public health, population density, housing conditions, access to clean water and the state of sewage and waste management systems as well as human behaviour.

All of these factors affect the transmission dynamics of a disease and determine whether or not it becomes an epidemic. But where climate is a consideration, temperature, relative humidity and precipitation will affect the intensity of transmission. Temperature can also influence the maturation, reproductive rate and survivability of the disease agent within a vector, or carrier.³³ So climate change will alter the distribution of the animals and insects which host dangerous pathogens, increasing or decreasing the range of their habitats and breeding places. Warmer average temperatures will provide a more hospitable environment for disease-carrying mosquitoes in many parts of Asia and the Pacific.

5 Natural disasters

Though sparse, the available evidence suggests that natural disasters are climbing in line with our warming planet. Of course, the impact of natural disasters may rise for reasons other than climate change. Population growth, higher levels of capital investment and migration to more disaster-prone areas are illustrative. But the insurance industry is adamant that the rise in the number of extreme and damaging climatic events is a significant driver of the upward trend. In its Sustainability Report of 2005, the Insurance Australia Group stated that, 'We are acutely aware of the impact of climate change on risks faced by the insurance industry. The past 19 out of 20 major insurance events in Australia have been weather-related.'³⁴

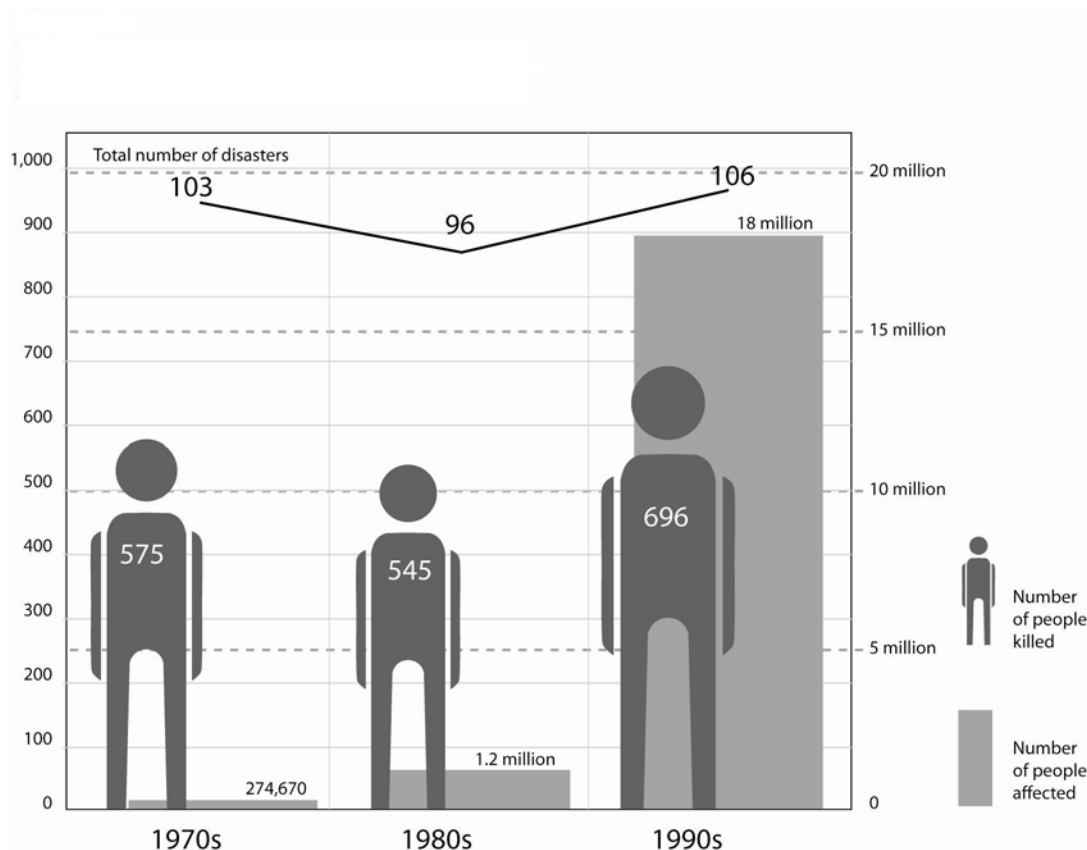
Figure 1 Great weather-related disasters, 1950–1999



Source: P. Vellinga and W.J. van Verseveld, Climate change and extreme weather events, Institute for Environmental Studies, World Wildlife Fund, September 2000, p 19.

Other reports claim that the number of people killed in the Oceania region by weather-related disasters rose 21% in the last three decades of the 20th century. This includes those affected by events such as cyclones, floods, landslides, droughts and extremes of temperature (Figure 2).³⁵ Around 188 million people were adversely affected by natural disasters in the 1990s, six times more than the 31 million directly or indirectly affected by war.³⁶

Figure 2 Reported hydro-meteorological disasters and their impact in Oceania (1970–1999)



Source: Walter, Jonathan, ed. *World disasters report 2002: focus on reducing risk*, Kumarian Press for the International Federation of Red Cross and Red Crescent Societies, 2002.

Although such statistics must be treated with caution since they are not yet sufficiently discerning to enable definitive judgements about cause and effect, they do suggest an upward trend in extreme weather events. Rather than being a once in a hundred years phenomenon, super storms may become more regular occurrences in the Pacific's cyclone belt, which affects northern Australia, most Pacific Island states and large parts of Southeast Asia.

Scientists are divided about whether this change is due to natural fluctuations or anthropogenic warming, although the differences are partly explicable by the rigorous scientific tradition, which requires a higher level of certainty than intelligence and national security analysts when considering risk. However, there is clearly a strong correlation between the steady rise in ocean temperatures attributable to anthropogenic greenhouse gas emissions and the demonstrable increase in storm frequency and intensity.³⁷ Hurricanes feed off warm water as trade winds blow over the ocean surface, pulling heat from the water as energy. Typically, large storms require ocean temperatures of 27°C, conditions which are now occurring much more regularly as tropical waters heat up. The strength of category 4 and 5 storms is a direct consequence of these warmer ocean temperatures.³⁸

Storms of this magnitude have a clear security dimension because of the death and destruction they bring in their wake and the political, economic and social stresses they place on even the most developed states. As temperatures increase, the scale and frequency of natural disasters is expected to rise in concert with extreme weather events, generating more humanitarian disasters requiring national and international relief. The Australian Defence Force and Australian Federal Police will have to shoulder the brunt of any increase in emergency and humanitarian operations in our immediate neighbourhood, as they are the only organisations with the resources and skilled personnel to respond quickly and effectively to natural disasters.

Natural disasters linked to climate change may prove an even greater security challenge for developing states, displacing affected populations, calling into question the legitimacy or competence of the national government and feeding into existing ethnic or inter-communal conflicts. In extreme cases, the survival of the nation itself may be in question. For example, the 1998 monsoon season brought with it the worst flood in living memory to Bangladesh, inundating some 65% of the country, devastating its infrastructure and agricultural base and raising fears about Bangladesh's long-term future in a world of higher ocean levels and more intense cyclones. In the absence of effective mitigation strategies, a one metre rise in sea level would flood about 17.5% of Bangladesh and much of the Ganges river delta which is the country's food basket.³⁹

Both the frequency and the severity of 'natural disasters' disproportionately affect low-income countries. In the last decade of the 20th century, 94% of all natural disasters and 97% of deaths due to natural disasters occurred in low-income countries. Around two-thirds of all disaster-related deaths occurred in South Asia alone. Moreover, the cost of natural disasters as a proportion of GDP was 20% higher in low-income than in high-income economies. The disproportionate impact of extreme events on low-income economies is due less to environmental factors than to the extreme vulnerability of the poorest sections of those communities. The poorest in society are often the most exposed to disaster risk. The capacity both to avoid and to recover from disasters is quite limited, and the probability that people affected by disaster will lose their lives or livelihoods is often high. People affected by natural disasters in low-income countries are reckoned by the International Red Cross and Red Crescent to be four times more likely to die than people affected by natural disasters in high-income countries.⁴⁰

6 Sea level rise and Asia-Pacific security

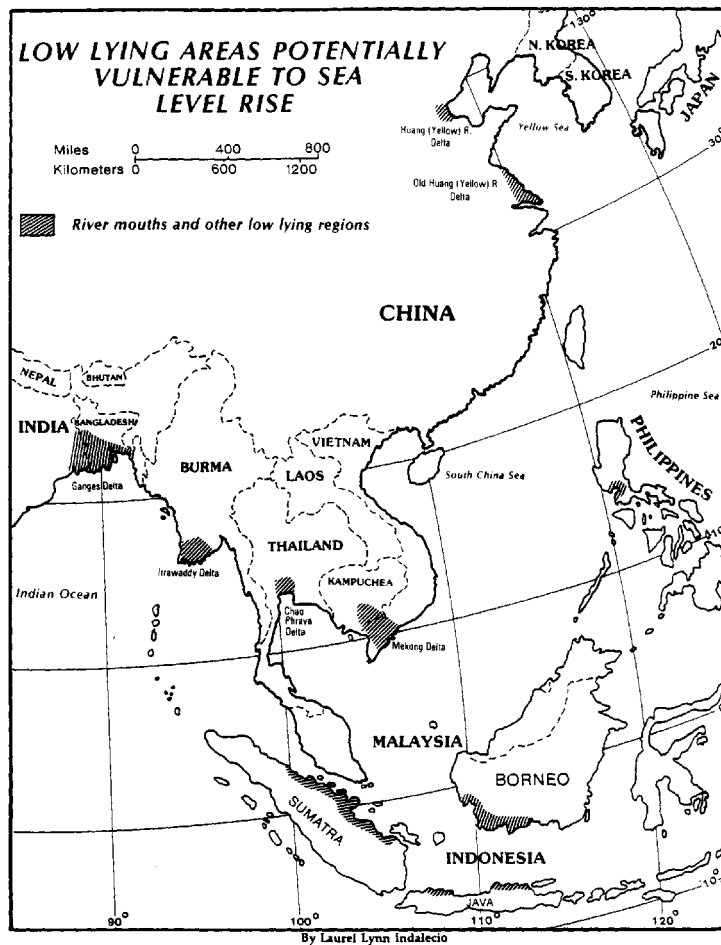
Bangladesh is not the only nation with a problematic future because of climate change. We know from a variety of independent studies that sea levels have risen by around 10cm globally over the past 55 years essentially because of the thermal expansion of water and the melting of terrestrial snow and ice.⁴¹ We also know that this rate of sea level rise is accelerating.⁴² Moreover, there is broad scientific consensus that glaciers around the world and the polar ice caps are melting at accelerating rates and seas are continuing to warm and expand.⁴³ The US National Snow and Ice Data Centre has concluded that human-induced warming is at least partially responsible for the shrinking of the Arctic ice cap, which will disappear entirely by 2060 at present rates of melt.⁴⁴ One potentially serious consequence of the loss of the permafrost of the northern hemisphere tundra region is the possible release of otherwise trapped carbon back into the atmosphere as methane or carbon dioxide, adding to the stock of greenhouse gases.

In the Southern Hemisphere, scientists believe that Antarctica will remain relatively stable for some hundreds of years, despite the Earth's warming, because most of the ice sheet is at a sufficiently high altitude that it will remain below melting point. While there has been a large loss of ice from the Antarctic Peninsula and a smaller observable melt in West Antarctica, the Antarctic ice sheet as a whole may actually grow in thickness because of increased precipitation from heavier snow falls as the atmosphere warms.⁴⁵ But there is no doubt that small, lower altitude glaciers are retreating.

Sea level rise may have particularly dire consequences for low-lying atoll countries in the Pacific, such as Kiribati (population 78,000), the Marshall Islands (population 58,000), Tokelau (population 2,000), and Tuvalu (population 9,000).⁴⁶ These small, islands are highly vulnerable to climate change because of their topography, high ratio of coast to land area, relatively dense populations and subsistence economies.⁴⁷ Periodic storm surges could well inundate up to 80% of the land area of North Tarawa and 54% of South Tarawa (Kiribati) by 2050, with the economic costs expected to range between 10 and 30% of GDP in any given year.⁴⁸ By 2080 the flood risk for people living on small islands will be on average 200 times larger than if there had been no global warming, and the risk could be even higher if the melting of polar ice continues to accelerate.⁴⁹ Ultimately, human habitation may not be possible on these islands, even with moderate climate change. If temperature and sea level rises are at the high end of those forecast, then the sea will either eventually submerge the coral atolls or ground water will become so contaminated by salt water intrusion that agricultural activities will cease.⁵⁰

Larger, more mountainous and populous islands such as Fiji and New Caledonia will also be seriously affected. In a worst case scenario of sea level rise, much of Fiji's productive land and urban areas would be flooded should the increase be at the upper end of the IPCC forecasts, exacerbating ethnic tensions over land.⁵¹ Inter-communal strife between indigenous Kanaks and French settlers could similarly be inflamed if productive land becomes scarcer and the Kanaks cannot sustain their agriculture and lifestyles on their ancestral land.⁵² For these reasons, climate change has risen to the top of the political agenda in the Pacific.

Map 1 Areas at risk from sea level rise in Asia



Source: Bardach, John E. Coastal Zone Activities and Sea level Rise. East-West Center, Hawaii. Environment and Policy Institute. Working paper no. 11 1988, p 8.

But rising sea levels pose far wider challenges to regional security than the survival of small island states in the Western Pacific. Most of Asia's densest aggregations of people and productive lands are on, or near, the coast, including the cities of Shanghai, Tianjin, Guangzhou, Hong Kong, Tokyo, Jakarta, Manila, Bangkok, Singapore, Mumbai and Dhaka. The areas under greatest threat are the Yellow and Yangtse River deltas in China, Manila Bay in the Philippines, the low lying coastal fringes of Sumatra, Kalimantan and Java in Indonesia, and the Mekong, Chao Phraya and Irrawaddy Deltas in Vietnam, Thailand and Burma respectively.⁵³

Many of these locations have not previously been susceptible to climate-induced risks and their vulnerability has increased due to extensive urbanisation and human settlement in coastal and riverine environments, exacerbated by extensive land use clearance. Heightening the risk is the fact that several large Asian cities are susceptible to cyclones driven by warm expanses of water that form in the west equatorial Pacific Ocean during summer. These cyclones produce strong tidal surges, especially in La Niña years, which can greatly increase the severity of coastal flooding and the consequent threat to lives, infrastructure, agriculture and fresh water.⁵⁴

Table 2 Potential land loss and population exposure to sea level rise in selected Asian countries

Country	Sea level rise	Potential land loss		Population exposed	
	(cm)	(km ²)	(%)	(millions)	(%)
Bangladesh	45	15,668	10.9	5.5	5.0
Bangladesh	100	29,846	20.7	14.8	13.5
India	100	5,763	0.4	7.1	0.8
Indonesia	60	34,000	1.9	2.0	1.1
Japan	50	1,412	0.4	2.9	2.3
Malaysia	100	7,000	2.1	>0.05	>0.3
Vietnam	100	40,000	12.1	17.1	23.1

Source: http://www.grida.no/climate/ipcc_tar/wg2/446.htm

Note: There are two estimates for Bangladesh.

7 Energy security

Almost all nations anticipate growth in energy usage in the coming decades. Australia's is expected to grow at around 2.1% per year through this decade and the next, most of which will be generated by conventional fossil fuels.⁵⁵ Globally, the International Energy Agency expects a 50% increase in fossil fuel usage over the next 15 years, which will dramatically push up greenhouse gas emissions without mitigating measures.⁵⁶ Climate change will complicate energy choices and heighten anxieties about future supplies of energy, particularly oil, as the transition from highly polluting fossil fuels to cleaner sources of energy gathers speed. In the short-term this may exacerbate oil shortages resulting from sudden price rises, distribution problems or disruptions to supply, adding to strategic uncertainty. Climate change, energy security and foreign policy are inextricably linked in other ways. The melting of the polar ice caps and accompanying sea level rise will throw into question established maritime boundaries and Exclusive Economic Zones (EEZs), creating tensions at sea that could impact on energy supplies and fuel interstate conflict in Australia's strategic backyard.

One aspect of the interrelationship between climate change and energy security that has received scant attention is the impact the submergence of small atolls, rocks and low lying islands, due to sea level rise, could have on the EEZs of maritime states and disputed sea bed resources, including oil and gas. This is a critically important issue since small rocks and islets are commonly used to delineate maritime boundaries and to claim vast tracts of ocean which would otherwise fall outside the EEZs of contiguous states or be designated high seas, opening them up to exploration and exploitation by other nations. International law currently provides no answer to the question of what would happen to sovereignty and EEZ claims should an island, or even country, be submerged.⁵⁷ In the event of significant sea level rise, the low water marks from which EEZs are measured would shift, raising the real possibility of serious, new maritime disputes as states argued about the criteria for resetting base lines and redesignating EEZs as high seas.

Rising oceans could complicate the resolution of disputed sovereignty claims in the Spratly Islands, a group of low lying atolls in the South China Sea which sit astride potentially rich deposits of oil and have already been the scene of military tensions between China, Vietnam and the Philippines. Some of these islands are already partially submerged and the highest (Southwest Cay) is only 4 metres above sea level.⁵⁸ Heightened tensions in the South China Sea could precipitate a crisis between Japan and China, ASEAN and China, or between rival ASEAN states. Both could disrupt Australia's sea trade with Asia and complicate attempts to reduce and eventually eliminate long standing territorial and resource disputes at sea.

Climate change is also forcing a major reassessment of the utility of nuclear power, once seen as the energy choice of last resort because of its tarnished public image as a dangerous and dirty fuel. Since nuclear power only emits about 25 grams of carbon dioxide equivalent per kilowatt hour compared with around 450–1250 grams for fossil fuels, it is the one source of virtual carbon free energy that can make a substantial difference to energy supply in the short to medium term.⁵⁹ Critics maintain that switching to nuclear power in order to reduce greenhouse gas emissions is misguided and merely replaces one problem with an even more serious one—the proliferation of plutonium and enriched uranium which can be used for manufacturing nuclear weapons. They contend that safely storing and protecting this material from terrorists and criminal groups intent on acquiring weapons grade material for use or profit is problematic, and the political and security risks too high.

But the security consequences of unmitigated climate change may well outweigh the risk of terrorists or rogue states acquiring nuclear material from expanded global stockpiles. The reality is that the world is already awash in nuclear material much of it stored in unsafe temporary storage sites located near nuclear reactors. In Northeast Asia, for example, approximately 50,000 tonnes of spent fuel are likely to be generated between 1990 and 2020, containing 450 tonnes of plutonium.⁶⁰ Even if all the nuclear power plants in the world were to be shut down tomorrow and every nuclear weapon dismantled, the accumulated waste of half a century would still have to be isolated, safeguarded and eventually disposed of—either in an underground repository or, less desirably, by reprocessing.⁶¹ So arguing against nuclear power on the grounds of safety does little to address existing problems of waste disposal or proliferation, and even less the issue of global warming.

8 Climate refugees

Ecological stress in the form of naturally occurring droughts, floods and pestilence has been a significant factor in forcing people to migrate since the beginning of recorded history.⁶² So has war-related environmental destruction. In the future, however, climate refugees could constitute the fastest growing proportion of refugees globally with serious consequences for international security. New migrants, regardless of whether or not they cross borders, can impinge on the living space of others, widen existing ethnic and religious divides and add to environmental stress in a self-sustaining cycle of migration and instability. By 2050, up to 150 million people could be displaced globally because of climate change, which would dwarf all other causes of refugees and unregulated population movements. Much of the anticipated impact will be in Asia, which already hosts more refugees and internally displaced people than any other region of the world. But climate change could add many more. Some 26 million people in Bangladesh are at risk from sea level rise, 73 million in China and 20 million in India.⁶³

Sea level rise, more frequent storm surges and other climatic factors with the potential to stimulate migration will increase over the course of many decades, allowing affected countries time to make adjustments and to ameliorate the effects. Government capacity will therefore be a critical determinant of the ability of societies to adapt and avoid climate-induced political disturbances and population movements. Most population displacements will not result in conflict or threaten human or state survival, and migration attributable to climate change will probably be internal, rather than transnational. Still, climate change is set to stretch the limits of adaptability and resilience in some developing states, overwhelming the carrying capacity of the land, disrupting traditional land management systems and making migration an attractive option to preserve quality of life.⁶⁴

Climate-induced migration is set to play out in three distinct ways. First, people will move in response to a deteriorating environment creating new or repetitive patterns of migration, especially in developing states. Second, there will be increasing short-term population dislocations due to particular climate stimuli such as severe cyclones or major flooding. Third, larger scale population movements are possible that build more slowly but gain momentum as adverse shifts in climate interact with other migration drivers such as political disturbances, military conflict, ecological stress and socio-economic change.⁶⁵ Even the benign effects of climate change could lead to conflict. For example, China's Xingiang province is likely to benefit from increased rainfall attracting an influx of Han migrants into the Muslim Uighur ancestral lands where tensions between the two communities are already on the rise and a low level insurgency is festering.

Australia will not be immune from the consequences of climate-induced migration in Asia and the Pacific. Although abrupt climate change triggering a massive exodus of environmental refugees is unlikely, significant population displacements caused by sea level rise, desertification, flooding and extreme weather are a distinct possibility. If affected states have sufficient time and resources to anticipate and plan for such exigencies then the security consequences will probably be minimal. However, poorer states could well be overwhelmed by the task confronting them in which case Australia may experience the ripple effects of climate-induced political disturbances and even violent conflict in the region. Should atoll countries become uninhabitable Australia will come under pressure to help resettle their people.

Australia and regional states need to give this issue more serious attention since three of the areas most vulnerable to sea level rise globally are in Asia and the Pacific (South Asia, Southeast Asia and low lying coral atolls in the Indian Ocean and the Pacific) and six of Asia's ten megacities are located on the coast (Jakarta, Shanghai, Tokyo, Manila, Bangkok and Mumbai). It is entirely possible, for example, that large areas of coastal Thailand, Malaysia and Indonesia will be permanently flooded by rising seas, forcing the relocation of many millions of people because governments will not have the resources to fund protective levy banks or other storm control measures.⁶⁶

However, it is difficult to see a surge of environmental boat people seeking to enter Australia illegally because of climate change. In Asia most of those internally displaced from environmental causes will find new homes within the boundaries of their native countries and those who do not will probably

seek refuge in states where they have strong cultural or ethnic ties. Thus Bangladeshis would seek refuge in neighbouring India or Pakistan, Indonesians from Sumatra would look to Malaysia while South Korea and China would be the preferred destinations for North Koreans. The number of Pacific Islanders at risk is relatively small and New Zealand is a much more likely destination for them. Tokelauans already have access to New Zealand, the inhabitants of Tuvalu have negotiated migration rights for nearly all of its citizens, while the Marshallese can settle in the United States under the Compact of Free Association. Of the Pacific Island states most threatened by sea level rise only the inhabitants of Kiribati have no real migration options.⁶⁷ Even an abrupt, catastrophic climatic event is unlikely to send a flood of people across borders, as the tsunami which devastated the Indonesian province of Aceh in early 2005 reminds us. The survivors will not have the physical resources or mental resolve to move very far from their homes.

9 Climate wild cards

These are some of the security consequences we can reasonably anticipate from the available scientific data. But what if the speed and extent of temperature increases is greater than forecast? Could it be that we have underestimated the threat? After all, climate researchers have identified several episodes of large scale, abrupt climate change over the past 100,000 years both prior to, and after, the last ice age.⁶⁸ In some instances rapid warming took place (as great as 16°C) over spans as short as a decade, although there is still substantial debate over how global these changes were.⁶⁹ So what could trigger abrupt, accelerated or runaway climate change and what strategic consequences might we expect?

There are several potential wild cards in the climate change deck. As greenhouse gas emissions increased during the latter half of the 20th century there was, at least for a time, an accompanying growth in airborne aerosols—primarily sulphate particles resulting from combustion processes—which mitigated the warming that might otherwise have occurred. These particulates scatter solar radiation, thereby releasing more energy to space, cooling the earth's surface and producing an effect known as 'aerosol masking' or 'global dimming'. Initially, the effect was confined to Europe and North America, as manufacturing surged and airborne pollution worsened in the immediate decades after World War II. But towards the end of the century, the concentration of particulates began to increase in Asia as first Japan, followed by the Asian tiger economies and then China and India emulated Europe and North America.

The so called 'Asian brown haze', which has become a semi-permanent feature of the region stretching from the northern Indian Ocean to China and much of Southeast Asia during summer, is graphic evidence of the rise in airborne aerosols in the developing world. The haze has global implications because it can travel half way around the world depending on the strength and direction of the prevailing winds. And it's getting worse.⁷⁰ It is conceivable that the real rate of global warming has been masked by the presence of these aerosols. In which case cleaning up the haze by moving towards alternative fuels and cleaner energy might paradoxically accelerate the rate of climate change.⁷¹

Another possibility is that deforestation will reach the point that the global biosphere will no longer act as a carbon 'sink' but instead, become a net source of carbon, warming the planet by a third more than scientists have forecast. There are also concerns about the stability of high latitude permafrost. There is clear evidence that ground which was once frozen all year round is melting at higher and higher latitudes. Although there are no definitive estimates of the volume of gases trapped under the permafrost they are thought to be considerable—perhaps as much as 500 billion tonnes, the equivalent of 70% of all carbon currently present in the atmosphere.⁷² This release could be quite rapid and widespread, as warming progresses, and would include a significant amount of methane gas which is one of the most damaging of the main greenhouse gases. Should this occur, then the IPCC projections of future global warming would have to be revised upward by a substantial margin, since they only take account of emissions from fossil fuel combustion.

Of all the potential climate wild cards, perhaps the greatest strategic risk is from a larger and more rapid than expected reduction of polar ice, which could dramatically increase sea levels, especially if parts of the Greenland ice cap were to melt. The US National Snow and Ice Data Centre has concluded that human-induced warming is at least partially responsible for the shrinking of the Arctic ice cap. We know from a variety of independent studies that sea levels have risen by around 10cm globally over the past 55 years, essentially because of the thermal expansion of water and the melting of terrestrial snow and ice.⁷³ Satellite data released in January 2008 indicates that West Antarctica is losing more ice than previously thought, with ice sheet loss along the Bellingshausen and Amundsen seas increasing by 59% over the past decade. If this trend continues, then Antarctic melt may also contribute to the expansion of our seas and the inundation of coastal and low lying areas.⁷⁴ If all the water trapped in the Antarctic ice cap as a whole, in Greenland, in the more vulnerable Western Antarctic Ice Sheet or in other glaciers and ice sheets were to melt, it is estimated that sea levels would rise by 56, 7.3, 4–6 and 0.15–0.37 metres respectively.⁷⁵

10 Assessing the climate change risk

The central conclusion of this analysis is that climate change will complicate and threaten Australia's security environment in several ways. First, weather extremes and greater fluctuations in rainfall and temperatures have the capacity to refashion the region's productive landscape and exacerbate food, water and energy scarcities in a relatively short time span. Climate-induced water scarcity clearly has adverse implications for food production. The region can ill afford a major drop in rainfall or a shift in distribution away from where it is most needed. If repetitive floods, or prolonged droughts, were to create even short-term food and water shortages during times of rising social and political tensions, regional governments might find themselves hard pressed to deal with these exigencies. Sea level rise is of particular concern because of the density of coastal populations and the potential for the large-scale displacement of people in the region. It will be extremely difficult to carry out forced evacuations or relocations without conflict and political disturbances.

Second, climate change will contribute to destabilising, population movements in Asia and the Pacific. Most of these flows are likely to be internal, but the ripple effects will be felt beyond the borders of the states most affected, requiring cooperative regional solutions. Energy dilemmas will be compounded by the need to reduce greenhouse gas emissions, requiring a more rapid transition away from our dependence on fossil fuels, or significant changes to the way they are used, than might otherwise have been the case. This could place added pressure on an already tight energy market and heighten anxieties about energy security. The submergence of reefs, rocks and small islands that are crucial in the adjudication of maritime energy and sovereignty claims could intensify resource disputes in the East and South China Seas.

Third, the economic and social costs of managing the deleterious effects of climate change are likely to be substantial, which could reduce growth, depress incomes and circumscribe the ability of developing states to meet the rising aspirations of their people. More extreme weather patterns would result in greater death and destruction from natural disasters adding to the burden on poorer countries and stretching the resources and coping ability of even the most developed nations. So-called once in a hundred year storms could well become common weather events along with more intense and prolonged droughts. The involvement of the ADF in emergency relief operations will intensify if the scale and frequency of climate-induced disasters increases. The ADF and the Australian Federal Police may also be more heavily committed in support of peace keeping and peace enforcement operations, particularly in the Southwest Pacific, should already fragile states be further weakened by the effects of climate change. This will have significant cost and manpower implications. Since 1999, ADF regional interventions have cost the federal budget on average over half a billion dollars every year, a figure which could rise significantly in the longer term as climate change begins to bite.⁷⁶

Fourth, extreme weather events and climate-related disasters trigger short-term disease spikes and also have more enduring consequences. Infectious diseases such as malaria, dengue and Ross River fever will become more widespread as the planet warms up, since temperature is a key factor in their prevalence. For developed countries like Australia, these disease concerns will usually remain within the public health arena, but this may not be the case for more vulnerable societies struggling to cope with other environmental and socio-political pressures.

Table 3 Level of vulnerability by country

High Vulnerability	China Hong Kong India Bangladesh Indonesia (especially northern Java, southern Kalimantan and eastern Sumatra) Thailand (especially the Chao Phraya Delta) Singapore The Philippines (especially Manila) Vietnam (especially the Mekong Delta) Cambodia Myanmar (especially the Irrawaddy Delta) Papua New Guinea Kiribati Tuvalu Vanuatu Fiji East Timor The Solomon Islands
Medium Vulnerability	Australia Japan North and South Korea Malaysia Laos Taiwan
Low Vulnerability	New Zealand

Fifth, even if not catastrophic in themselves the cumulative impact of rising temperatures, sea levels and more mega droughts on agriculture, fresh water and energy could threaten the security of Australia's neighbours by reducing their carrying capacity below a minimum threshold, thereby undermining the legitimacy and response capabilities of their governments. In effect, climate change acts as a stress multiplier on all societies and states. While richer states like Australia may be better positioned to manage the consequences of climate change, they cannot be inoculated against its destabilising effects. In an interconnected world, the problems of the least developed states can quickly become the problem of all.

Sixth, should climate change coincide with other transnational challenges to security, such as terrorism or pandemic diseases, or add to pre-existing ethnic and social tensions, the impact will be magnified. State collapse and destabilising internal conflicts is a more likely outcome than inter-state war. Based on the evidence to-date it is difficult to see climate change alone producing major reconfigurations of the regional or global balance-of-power in the foreseeable future. Shifts of this order presuppose substantial redistributions of the relative productive capacities of nation states, but current climate models are still not accurate enough to describe in detail how most individual states will be affected. States weakened by climate change could become breeding grounds for terrorists, insurgents and fundamentalists of various political and ideological hues, which will have wider geo-political consequences. This could include the heightened incidence of resource disputes over the ownership of fish, fresh water and energy resources, including in the deep oceans and Antarctica. For a handful of small, low-lying Pacific nations, climate change is the ultimate security threat since rising sea levels will eventually make their countries uninhabitable.

Far from exaggerating the scale of climate change it is possible that scientists may have underestimated the threat. The most concerning climate wild card is an accelerating reduction of land-based glaciers and the polar ice which could dramatically increase sea levels, especially if part of the Greenland ice cap and West Antarctic were to melt. Should this eventuate, then the more extreme and currently improbable climate change scenarios would become real possibilities, raising the prospect of major geo-political disturbances that could seriously derail Australia's economic development and jeopardise national security.

In assessing the long-term consequences of climate change for international security we should be mindful of Jared Diamond's warning. In his study of the reasons for the collapse and survival of societies, Diamond observed that in many historical cases a society that was depleting its environmental stocks could absorb losses as long as the climate was benign, but when it became more variable or harsh these societies were pushed over the edge and even collapsed. It was the combination of environmental impact and climate change that proved fatal.⁷⁷ Whether or not Diamond's observations are germane to our milieu remains to be seen, but can we afford to ignore the risk? It is a sobering fact that on four out of five occasions of mass extinction in the Earth's history, at least half of all animal and plant species are estimated to have been wiped out during periods of warming that are comparable to those in prospect.⁷⁸

In the security domain, strategic doctrines and defence budgets are frequently justified on the basis of far less observable evidence than we have about the climate future which awaits us. Yet very little has been done to research, address or even conceptualise the potential security implications of climate change internationally. Prudence and sensible risk management suggest that policy makers need to take this issue far more seriously. And our strategic planners ought to include worse case climate change scenarios in their contingency planning as they do for terrorism, infectious diseases and conventional military challenges to national security. For climate change may well be the threshold event that pushes our already stressed planet past an environmental tipping point from which there will be no winners.

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