

## Chapter 1

# An Introduction to Climate Change Litigation

## 1. Introduction

An overwhelming body of scientific reports shows that global warming is a major threat to populations, human health and property and, if left unchecked, civilisation itself. Global warming will impact adversely on many aspects of human needs, such as the supplies of food and fresh water, the availability of fertile land and sustainability of ecosystems. Rises in sea level will inundate low-lying land and cities whilst an increase in storms and heat waves will facilitate the spread of disease and injury.

In the absence of mandatory requirements on governments and corporations to reduce greenhouse gas emissions, advocacy groups, public authorities and individuals are turning their attention to the courts to seek compensation from, and to penalise, governments and organisations thought to be contributing to global warming. This emerging class of legal actions, known as climate change litigation, raises a host of highly complex legal and scientific issues.

### a. Global warming

In the view of most commentators, the debate about global warming and whether it is being caused by anthropogenic (ie. human induced) or natural causes has already taken place and has concluded in favour of the position supported by an overwhelming body of scientific evidence: namely, that global warming is occurring and that it is largely due to anthropogenic causes. For example, British Prime Minister Tony Blair has said:

Climate change is the world's greatest challenge. It is now plain that the emission of greenhouse gases, associated with industrialisation and economic growth from a world population that has increased six-fold in 200 years, is causing global warming at a rate which is unsustainable.<sup>1</sup>

Similarly, the Republican Governor of California, Arnold Schwarzenegger, has said that "...the debate is over...[g]lobal warming, and the pollution and burning of fossil fuels that cause it, threatens every person on the planet".<sup>2</sup>

NASA has reported that 2005 was the hottest year recorded since 1880 when reliable instrumental records first became available, although the US Government's National Climatic Data Center has said that 1998 was equally hot. Indeed, nineteen of the hottest 20 years on record have occurred since 1980.<sup>3</sup>

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1 T. Blair "Foreword" to H.J. Schellnhuber (ed.), *Avoiding Dangerous Climate Change* (Cambridge University Press, Cambridge, 2006) at p.vii, available from <<http://www.defra.gov.uk/environment/climatechange/internal/dangerous-cc.htm>> viewed at 20 May 2006.

2 A. Schwarzenegger, "Cool Thinking," *New Scientist*, 21 January 2006, at p.18.

3 G. Lean, "World Is At Its Hottest Since Prehistory, Say Scientists", *The Independent* (online), 20 December 2005.

The “greenhouse effect” and “global warming” are terms with which most people are familiar. However, in the context of climate change litigation, it is important to emphasise that they are related, but separate, processes.

The physical processes of the greenhouse effect have been known since the early 19<sup>th</sup> century.<sup>4</sup> The effect was first noticed by French scientist and mathematician Jean-Baptiste Fourier (1768-1830). The greenhouse effect in the atmosphere is similar to the “blanketing effect” created by the glass panels of a greenhouse, although, unlike the atmospheric greenhouse effect, the higher temperature in agricultural greenhouses is also due to a reduction in air movement. Generally, the atmosphere is penetrated by solar radiation (light and ultraviolet radiation). Some of this energy is re-radiated from the earth’s surface as infrared radiation (heat). Infrared radiation has a longer wavelength than other types of solar radiation which means that it is absorbed by atmospheric greenhouse gases, such as carbon dioxide and methane. Consequently, the average temperature of the earth and atmosphere increases by more than it would if this “radiation blanket” effect did not occur. This greenhouse effect, which is a natural process necessary for the maintenance of life, is referred to as “radiative forcing”. It has been calculated that an atmosphere consisting entirely of nitrogen and oxygen (which do not absorb or emit thermal radiation) would have an average global temperature of -6°C at the surface, a difference of around 21°C, compared with the Earth’s present average surface temperature.<sup>5</sup>

In the context of global warming, plaintiffs and scientists are not concerned about the “natural” greenhouse effect (which is necessary for the maintenance of life) but, rather, the “enhanced greenhouse effect” which is due to increases in the atmosphere of carbon dioxide, methane, nitrous oxide and halogenated compounds as a result of human activities. The greatest contribution to the enhanced greenhouse effect is from increases in carbon dioxide which arise from the burning of coal, oil and gas and from deforestation. Scientists have shown that the concentration of carbon dioxide in the atmosphere has risen by about 30 per cent since pre-industrial times (which is unprecedented in recorded history) and is increasing at 0.4 per cent per year.<sup>6</sup> As a result, the average temperature of the earth has risen 0.7°C, which represents a 5 per cent rise on the average temperature of 14°C. This rise in temperature is highly significant in terms of the damaging impact that it could have on the earth.

Temperature rises on earth can occur due to a variety of natural causes, such as variations in the intensity of solar activity and emissions of carbon dioxide during volcanic eruptions. This distinction between natural and human-induced global warming is of fundamental importance in the field of

4 J.T. Houghton, *The Physics of Atmospheres*, 2nd edition (Cambridge University Press, Cambridge, 1986); L.D. Danny Harvey, *Global Warming: The Hard Science* (Prentice Hall, London, 2000).

5 J. Houghton, *Global Warming: The Complete Briefing* (Cambridge University Press, Cambridge, 2004), p. 16.

6 J.T. Houghton (et al) (eds.), *Climate Change 2001: The Scientific Basis* (Cambridge University Press, Cambridge, 2001), p. 92 available through <<http://www.ipcc.ch>> viewed at 20 May 2006.

climate change litigation as a plaintiff will need to establish not only that the harm in relation to which its action is being brought has arisen from global warming, but also that global warming was caused in part by the defendant. The latter part of this argument necessarily entails proving that climate change is, at least in part, human-induced and is not due to natural climatic variability. Although the scientific consensus is that global warming is occurring and is being caused by human activities, global warming sceptics and their proponents (often carbon emitting-corporations and other potential defendants to climate change lawsuits) argue that global warming is not taking place, or, if it is, that it is due to natural climatic variability rather than human activity.

Scientific studies have shown that, for about 1,000 years before the industrial revolution, the amount of greenhouse gases in the atmosphere was constant. Indeed, US and European scientists who have analysed the concentration of gas trapped in Antarctic ice deposited during the past 650,000 years have found that current levels are 27 per cent greater than the highest concentrations for any other time during the 650,000 year period. Gas levels were last that high, according to Professor Sir David King, a former Chief Scientist of the British Government, in the palaeocene epoch (which began about 65 million years ago and lasted for about 11.5 million years) during which there was a period of rapid warming and in which a massive reduction in life occurred.<sup>7</sup>

Land areas have warmed more than oceans<sup>8</sup> and mean sea level has increased at an average annual rate of 1 to 2 millimetres during the 20<sup>th</sup> century.<sup>9</sup> According to the Intergovernmental Panel on Climate Change (IPCC) – a body established by the World Meteorological Organisation and United Nations Environmental Programme in 1988 to assess scientific, technical and socio-economic information regarding climate change – there will be an increase in the globally averaged surface temperature of 1.4 to 5.8°C over the period 1990 to 2100.<sup>10</sup> The IPCC has said that this “is about two to ten times larger than the central value of observed warming over the 20<sup>th</sup> century and the projected rate of warming is very likely to be without precedent during at least the last 10,000 years, based on paleoclimate data”.<sup>11</sup>

### **b. Harm caused by global climatic change: sources for litigation**

Based on scientific research, global warming will have a major impact on the environment which, in turn, will cause severe damage to human health and property. It is thought that global warming will have some limited benefits in the short term and in specific contexts (for example, an initial increase – before a decrease at higher temperatures – in the productivity of plants<sup>12</sup> and reduced

7 Lean, above n 3.

8 R.T. Watson (et al) (eds.), *Climate Change 2001: Synthesis Report* (Cambridge University Press, Cambridge, 2001), at p.5 available through <<http://www.ipcc.ch>> viewed at 20 May 2006.

9 Ibid p.6.

10 Ibid p.8.

11 Ibid p.8.

12 Ibid pp. 8-9.

cold stress mortality in temperate countries); however, adverse effects will heavily and increasingly outweigh any positive effects.

Scientific evidence regarding climate change is set out in Chapter Four. However, in the context of obtaining an overview of the harm that global warming is likely to cause (and the potential for types of damage that may lead to climate change lawsuits), it is useful to consider some examples of the severe effects that climate change is expected to have on the environment.

Scientific studies have shown that Arctic ice is rapidly melting, with the quantity of ice being 20 per cent less than previous years during the summer of 2005. Some researchers, such as Dr Mark Serreze of Colorado's National Snow and Ice Data Center, believe that a threshold may soon be reached beyond which sea ice will not recover.<sup>13</sup> This may result in a feedback process in which there will be less white ice to reflect sunlight back into space and more open blue water to absorb solar energy, causing an acceleration in the melting of ice.<sup>14</sup> The permafrost in the tundra of Siberia is also melting rapidly and is releasing frozen stores of the greenhouse gas methane.<sup>15</sup> British scientists have also discovered another feedback mechanism whereby warmer temperatures cause increased microbial activity in soil which, in turn, produces carbon dioxide and as such causes further releases of the gas that were not previously known. These increases could be in sufficiently large quantities to impact negatively on Britain's attempt to curtail greenhouse gas emissions by moving away from coal.<sup>16</sup>

Greenland's glaciers are melting into the sea at almost twice their previously observed melt-rate in the last five years.<sup>17</sup> Greenland's glaciers and those of Antarctica constitute potentially the largest contribution to global sea level rise. Greenland's ice sheet covers 1.7 million square kilometres with ice up to 3 kilometres thick. Its complete melting would raise global sea levels by an estimated 7 metres, having a devastating impact on coastal cities and communities. Over the past 20 years the average temperature of Greenland has risen by 3°C. Between 1996 and 2006, the amount of water lost from Greenland's ice sheet increased from 90 cubic kilometres to 220 cubic kilometres per year. There is scientific debate about the exact mechanism causing the accelerated melting (it is thought that increased temperatures may either loosen the bond between glaciers and the underlying bedrock or melt floating shelves on the shore which hold the ice in place<sup>18</sup>), but there is a general consensus that the accelerated melting is due to warming around the glaciers.

If global warming merely impacted upon coastal zones through sea level rises, this factor alone would make global warming a major legal – leaving aside social and political – issue. For example, the value of coastal land at risk of being lost in Poland has been estimated at US\$30 billion and the cost of protecting 2,200 kilometres of coast against sea level rises at US\$6

13 B. McKibben, "The Coming Meltdown," *The New York Review of Books*, vol. 53, no.1, 12 January 2006, at <<http://www.nybooks.com/articles/18616>> viewed at 20 May 2006.

14 Ibid.

15 F. Pearce, "Dark Future Looms for Arctic Tundra," *New Scientist*, 21 January 2006, at p.15.

16 "CO2 Figures Break Kyoto Vows", *New Scientist*, 8 October 2005, at p.7.

17 E.Rignot and P. Kanagaratnam, "Changes in the Velocity Structure of the Greenland Ice Sheet", *Science*, vol. 311, 17 February 2006, pp. 986-990 (DOI:10.1126/science.1121381).

18 Ibid.

billion.<sup>19</sup> The Heinz Center estimated that about 1,500 homes in the United States are lost each year due to coastal erosion (accelerated by global warming) at a cost of US\$530 million per annum.<sup>20</sup> It has been estimated that a 0.5 metre sea level rise by 2100 would cause damage to US coastal property in the order of US\$20-150 billion.<sup>21</sup>

Over the last 40 years, there has been a large increase in the global inflation-adjusted losses from ordinary and extreme weather events. In particular, figures show that there has been a more than tenfold increase in such losses from US\$3.9 billion per year in the 1950s to US\$40 billion per year in the 1990s.<sup>22</sup> The insured portion of these losses rose from a negligible level to US\$9.2 billion. Causes of these disaster losses are thought to be due partly to physical factors, such as climate change, and partly due to socio-economic factors, such as increased urbanisation.<sup>23</sup>

The trend of increasing costs due to weather-related disasters is likely to accelerate with global warming. The US National Oceanic and Atmospheric Administration rated 2005 as the most turbulent on record, with 26 named storms, 13 of which were strong enough to be rated as hurricanes on the Saffir-Simpson scale and 7 of which were major hurricanes. This represents five major hurricanes above the average for the Atlantic season.<sup>24</sup> Hurricane Katrina was the most destructive hurricane to hit the US in recent times, devastating the city of New Orleans, killing approximately 1,000 people and leaving estimated repair costs of US\$235 billion.<sup>25</sup>

Until recently, meteorologists believed that the upsurge of hurricanes over the last few decades was not adequately explained by global warming. However, a shift in scientific opinion is occurring which sees the upward trend in tropical cyclones' destructive potential (tropical storms are 60 per cent longer and wind speeds up to 15 per cent higher than previous averages of tropical storm duration and wind speeds) as a product of global warming.<sup>26</sup> Of course, this does not mean that, for example, Hurricane Katrina would not

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19 R.B. Zeider, "Climate Change Vulnerability and Response Strategies for the Coastal Zone of Poland," *Climatic Change*, vol. 36, 6 May 1997, pp. 151-173.

20 Heinz Center, *The Hidden Costs of Coastal Hazards. Implications for Risk Assessment and Mitigation* (Island Press, Washington DC, 1999).

21 J.E. Neumann (et al), *Sea-Level Rise and Global Climate Change: A Review of Impacts to US Coasts* (Pew Center on Global Climate Change, Arlington, 2000).

22 J.J. McCarthy (et al) (eds.), *Climate Change 2001. Impacts, Adaptation, and Vulnerability* (Cambridge University Press, Cambridge, 2001), at p.13, available through <<http://www.ipcc.ch>> viewed at 20 May 2006. The figures are in 1999 US dollar terms and are unadjusted for purchasing power parity.

23 Ibid. See further, L.A. Berk and W.A. Schreiner Jr., "Rising Temperatures, Seas and Claims: The Potential Impact of Climate Change on Property Insurance Claims," *Risk Management Magazine*, March 2006, pp. 16-21.

24 S. Connor, "Scientists Warm to Hurricane Theory," *The Independent Weekly*, 11-17 December 2005, p.10.

25 Ibid.

26 K. Emanuel, "Increasing Destructiveness of Tropical Cyclones Over the past 30 Years." *Nature*, vol. 436, 4 August 2005, pp. 686-688 (DOI:10.1038/nature3906); R.A. Pielke, "Meteorology: Are There Trends in Hurricane Destruction?" *Nature*, vol. 438, E11 (22 December 2005), (DOI:10.1038/nature 04426); C.W. Landsea, "Hurricanes and Global Warming," *Nature*, vol. 438, E11 (22 December 2005) (DOI:10.1038/nature04477).

have occurred if there had not been any human-induced global warming. Rather, it means that the statistical probability of severe cyclones, such as category 4 and 5 cyclones, has increased significantly due to human-induced global warming and, in the context of legal tests of causation (see Chapter Four), this is of key importance.<sup>27</sup>

According to insurance company Munich Re Foundation, the cost of the 2005 hurricane season was a financial loss of over US\$200 billion (excluding the costs of rebuilding New Orleans). Insurance claims were over US\$70 billion.<sup>28</sup> The most costly year prior to 2005 had been 2004 in which economic losses of about US\$145 billion were incurred with insurance claims of US\$45 billion having been made. The UN Environment Program has said that these losses are due to the highest number of hurricanes and tropical storms on record.<sup>29</sup>

These examples demonstrate just some of the severe impacts that global warming can have. A broader overview of the types of harm that are likely to be caused by global warming is provided in Figure 1.1. This diagram shows some of the major types of damage to property and health that global warming is likely to cause, as well as the interactions and feedbacks between these effects on property and health. Importantly, the types of harm are likely to vary greatly according to financial and other resources available to victims. For example, whereas loss of homes and livestock from storms may have relatively few flow-on health effects for persons in developed nations (as they have resources to mitigate such losses), this may have devastating effects in undeveloped nations where such damage could amount to irreplaceable losses of shelter, food, transportation and even fuel (where, for example, dung is burned for heat and cooking), which, in turn, could lead to severe mental and physical health effects as a result of exposure to the elements and disease. Figure 1.2 expands on the types of impacts global warming is likely to have by providing an overview of some of the broader effects on human, economic and natural systems. The diagram does not, however, provide an exhaustive list of the large number of impacts that could result from global warming.

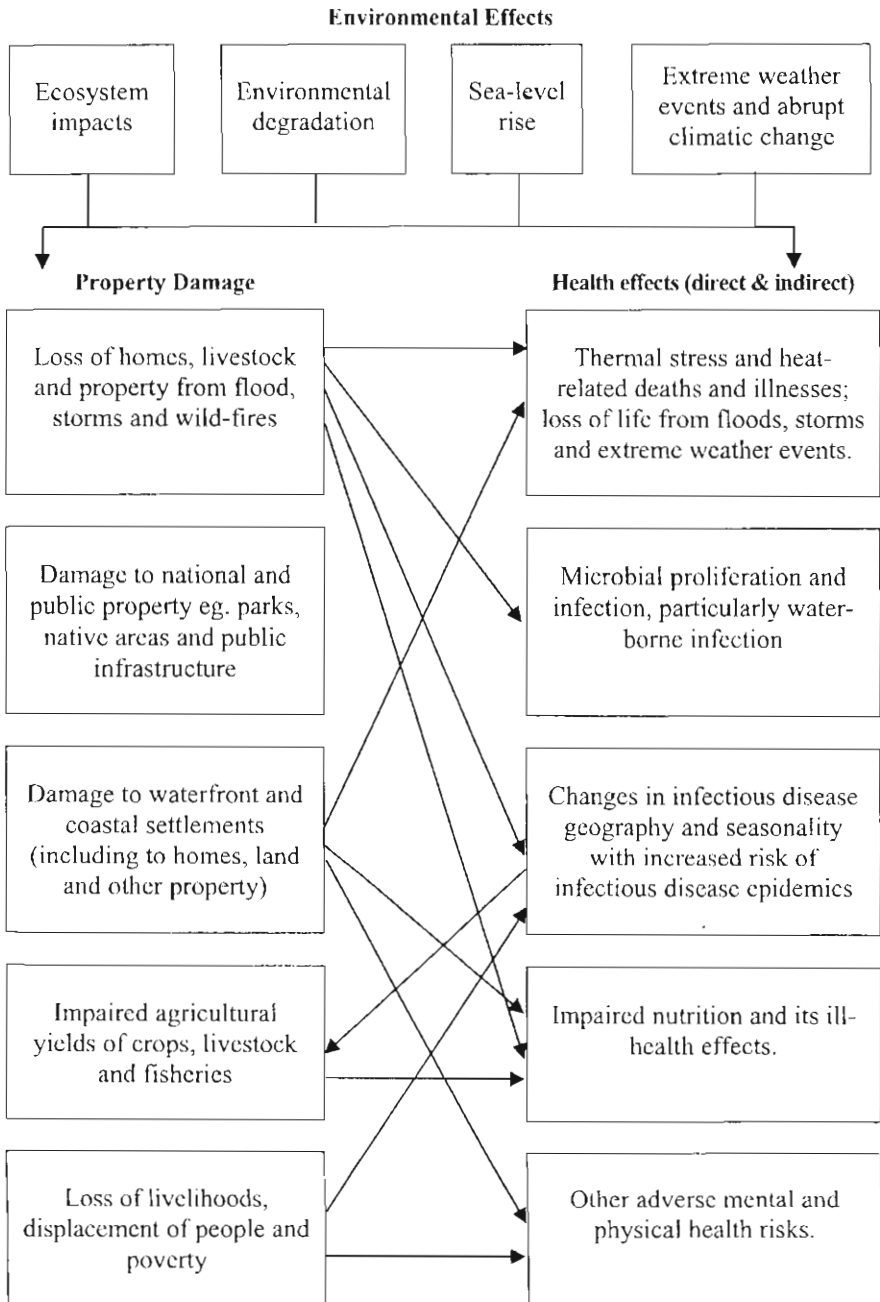
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27 The scientific complexities involved in this area can be illustrated with a brief examination of the issues associated with tropical cyclone formation. Tropical cyclones require an initial pillar of humid air over the sea with a temperature greater than 26°C. Warming of the oceans by global warming increases the probability of the initial formation conditions being met. However, as hurricane formation depends on the *relative* temperature differences between the air and ocean, a warming world could have a warmer atmosphere, in turn reducing the temperature differential. As well, stronger winds generated by global warming could “chop up” the sea, thereby cooling it, and may also break up the pillar of humid air needed for initial hurricane formation. These factors – and many others – all mutually interact.

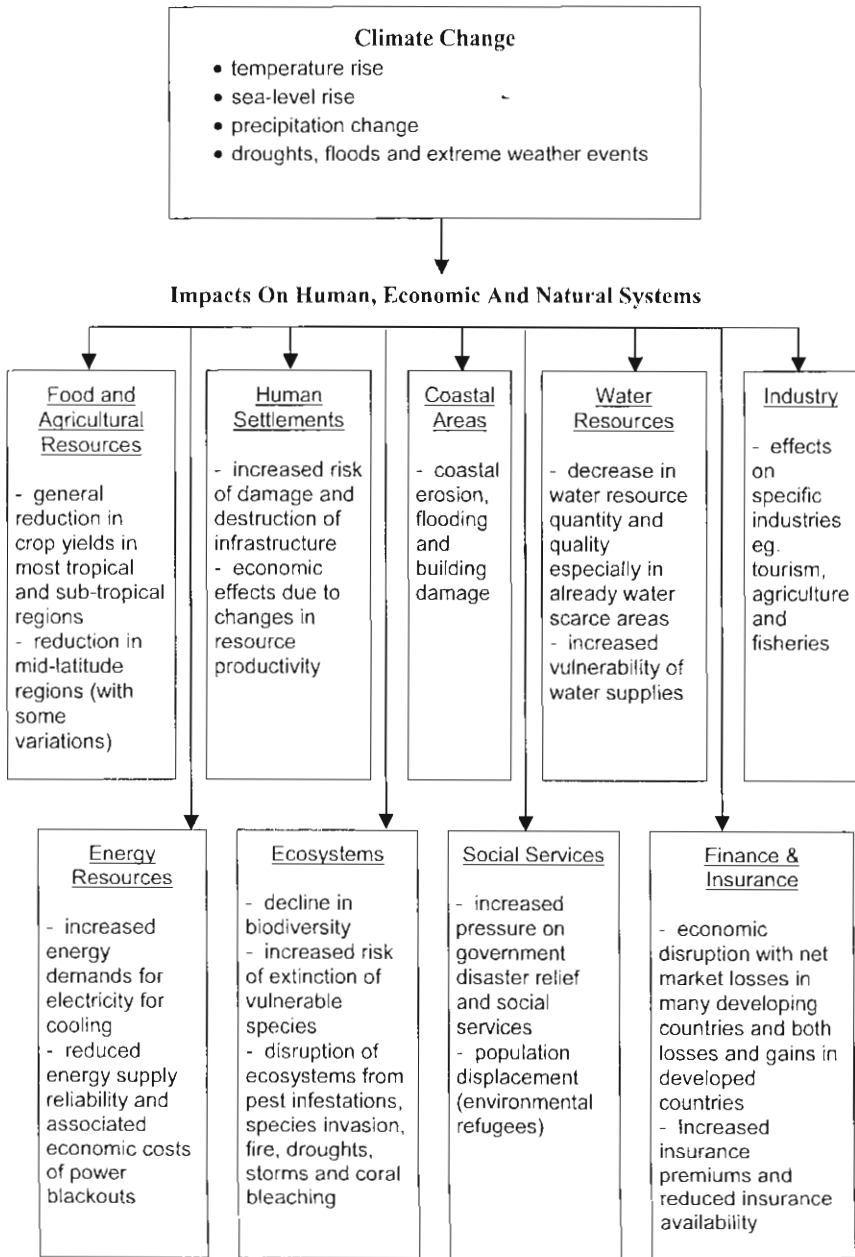
28 Conner, above n 24.

29 Ibid.

**Figure 1.1: Harms Caused by Global Warming:  
Mutual Interaction and Feedbacks**



**Figure 1.2: The Impact of Global Warming On Human, Economic and Natural Systems**



### c. Holding entities liable for global warming: a far-fetched idea?

If climate change lawsuits are to have real prospects of success, a hurdle that will need to be overcome – at least amongst potential plaintiffs and the legal community – is the perception that it seems fanciful, or far-fetched, that an organisation can, or should, be held liable for heating up the environment. However, when considered from a jurisprudential and philosophical perspective, there is little reason as to why governments and corporations cannot, or should not, be held liable for harms resulting from global warming if they have contributed to those harms.

It is a fundamental principle of legal systems around the world that persons should be held accountable for damage that they cause. For example, in the context of civil actions, this is reflected in the principles of both tort and contract law as well as legislation. For example, an organisation emitting a highly toxic chemical into a public waterway in Australia could generally be held liable under environmental legislation for resulting damage to persons and the environment in most, if not all, State jurisdictions. There is little reason as to why – based on these same principles – an entity that causes harm by emitting greenhouse gases should not be held accountable for harms that result from those actions. Two major characteristics of climate change suits that differentiate them from more familiar cases involving harm or damage (such as other types of environmental and anti-tobacco suits) are that, firstly, the causal chain involved is significantly longer and more complex and, secondly, the types of harm caused are considerably more widespread. However, provided there is sufficient evidence to meet the applicable standards of proof for the types of harm caused, neither of these points provides a valid reason for avoiding liability. Legal history is littered with examples of where the law has been hesitant to apply its principles to large scale incidents. Take, for example, cases of murder and genocide: history shows that culprits guilty of committing single murders are often brought to justice whereas leaders of nations guilty of genocide sometimes escape prosecution, leading to the adage that it is easier to get away with mass murder than killing a single person. Similarly, in the context of climate change litigation, it is largely the scale of harms involved that leads to the perception that it is too far-fetched to hold greenhouse gas emitters liable for their actions or that, for some reason, this type of harm is “different” to other types of harm. This perception will need to be overcome if climate change suits are to reach their full potential.

Of course, there are always exceptions to legal principles. Modern industrial societies and, arguably, all human societies, harm the environment to some extent. The comforts of modern life are not possible without some environmental damage. In view of this, environmental statutes, for example, usually set some minimal level of legally permissible pollution, sometimes even for chemicals which can be highly toxic in concentrated forms. As such, there is an element of legitimacy to the argument that global warming is “the price of civilised life”. Further, a large number of people in industrialised and other nations benefit from the comforts produced by modern industry and, if there is an environmental cost, it should be met by this group of people as a whole and not just entities that are directly responsible for greenhouse gas emissions. However, as addressed in later chapters, these are tenuous

arguments in view of factors such as the predicted severity and scale of harms involved and the lack of alternatives available to consumers.

#### **d. Aims of litigation**

Plaintiffs to climate change suits are likely to fall into one of two general categories when grouped according to their objectives: firstly, those seeking compensation for harm caused by global warming; and, secondly, those seeking to use litigation to prevent or reduce further global warming. The former are likely to comprise largely of individuals – probably as part of class actions – and the latter of environmental and other public interest groups. The goal of preventing or reducing anthropogenic global warming is likely to be achieved either directly, by seeking injunctive relief in relation to polluting and other relevant acts, or indirectly, by creating disincentives – in the form of increased liability and other commercial risks (see Chapter Six) – to engage in such acts.

Climate change litigation is likely to play an important role in future environmental reform. Firstly, lawsuits, whether successful or not, focus public attention upon key issues through media exposure and can be effective in influencing governmental and corporate policies. A prime example of this has been in the area of anti-tobacco litigation where lobbyists have successfully maintained media focus on anti-tobacco lawsuits in order to influence policies regarding smoking. Secondly, if either litigation or the possible future settlement of cases results in a need for industry to take measures to reduce the impact of their activities on global warming – for example, by reducing carbon dioxide emissions – in order to avoid potential future liability, this would create a great deal of uncertainty for businesses as to precisely what measures they would need to take. Further, it could also lead to different steps being required to be taken in different jurisdictions, effectively imposing on industry a complex and costly compliance regime. Such a scenario would likely result in national governments being forced, probably through the lobbying of industry itself, to address climate risks through legislation or other forms of regulation in order to provide, amongst other things, certainty for business.

The first climate change actions were brought in the late 1990s and several important cases have been heard since. Whilst few of the actions to date have proceeded to successful conclusions for plaintiffs, a key objective in bringing these lawsuits has been to lay the foundations for future litigation. Subsequent cases will build upon the legal arguments and scientific evidence presented in these seminal cases.

### e. Public law vs. private law actions

An important distinction in the context of climate change litigation is the difference between public law and private law actions. Public law is the body of law that deals with powers, rights and obligations of government (particularly those of agencies and public offices). Major fields of public law include administrative, constitutional, criminal and international law. Private law is the body of law that deals with legal relationships (i.e. specific rights, duties and obligations) between private persons, including corporations. This distinction is important as climate change actions will be based in both public law and private law and rights and remedies vary greatly between the two. For example, an environmental group may seek judicial review of an administrative action by a government body, such as an environmental protection agency, under public laws to enforce obligations it has to protect the environment and which the group feels the agency is not fulfilling. At the same time, the group could commence private law actions against individuals and corporations who have benefited from the agency's failure to exercise its public duties and who are engaging in pollution and the creation of environmental harm. Public and private law actions are addressed in Chapters Two and Three respectively.

## 2. Potential Parties

A significant proportion of climate change litigation cases are likely to be brought in countries such as Australia and the United States, these two nations being the first and second highest per capita greenhouse emitting nations in the world respectively and amongst the few developed nations that have refused to sign or ratify the *Kyoto Protocol to the United Nations Framework Convention on Climate Change* (Kyoto Protocol) for the reduction of greenhouse gas emissions. China and India are, as developing countries, presently exempt from the Kyoto Protocol (to which they are signatories); however, their rapid paces of development now and in the future could mean that they may find themselves in similar positions to those of the United States and Australia, particularly if they maintain their present rates of economic growth without curbing greenhouse gas emissions.

Countries that ratify the Kyoto Protocol are committed to reducing their collective emissions of carbon dioxide and five other greenhouse gases (or, if these gas levels are increased, to engaging in emissions tradings with other nations) by 5.2 per cent relative to the year 1990. The Kyoto Protocol entered into force on 16 February 2005. The United States, although a signatory, has not ratified the protocol, believing that to do so would seriously harm its economy.<sup>30</sup> The United States also objects to developing nations that are high greenhouse gas emitters, such as China and India, being entirely exempt from the requirements of the protocol. Australia has refused to sign the protocol on

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30 President George W. Bush, "President Bush Discusses Global Climate Change," 11 June 2001 at <<http://www.whitehouse.gov/news/releases/2001/06/20010611-2.html>> viewed at 20 May 2006.

the grounds that, whilst the Kyoto Protocol has some positive elements, "it does not provide a comprehensive or environmentally effective long-term response to climate change".<sup>31</sup> The United States and Australia, as well as the Kyoto Protocol nations of China, Japan, India and South Korea, have entered an alternative agreement known as the *Asia Pacific Partnership on Clean Development and Climate* (APPCDC), which was signed at the Association of Southeast Asian Nations (ASEAN) regional forum on 28 July 2005. The signatory countries use about 45 per cent of the world's energy and emit over half of the world's carbon dioxide per annum. The APPCDC, in contrast to the Kyoto Protocol, does not impose legally binding requirements to reduce emissions of greenhouse gases by any fixed amounts, but, rather, urges signing nations to voluntarily develop "clean technologies" to deal with the problem of global climate change caused through human greenhouse gas emissions. Opponents of the APPCDC argue that the agreement is merely a smoke-screen to enable major coal using and producing nations to continue with business-as-usual. This suggests that nations that are party to the APPCDC, as well as polluting organisations operating within them, could also be likely targets for climate change lawsuits.

#### **a. Plaintiffs: individuals, public interest groups & governments**

Potential plaintiffs for climate change lawsuits are numerous. As shown in Figures 1.1 and 1.2, the types of harm likely to be caused by global warming are extremely varied, leading to an equally diverse group of potential claimants. As the effects of climate change will be global, potential plaintiffs exist in countries around the world. It is possible that a disproportionate number of plaintiffs could be located in non-industrialised nations in view of the fact that the adverse impacts of global warming are likely to disproportionately affect developing nations and impoverished people who lack the financial and technological capacities required to adapt to the challenges of global climate change.<sup>32</sup> Due to the varied types of harm likely to be caused, it is difficult to meaningfully identify and categorise potential plaintiffs. However, broadly speaking, plaintiffs are likely to fall into one of three groups.

Firstly, plaintiffs are likely to include those who personally and directly suffer harm as a result of global warming. This may include, for example, individuals (or groups of individuals in class actions) who suffer damaging health effects, businesses or industry associations in sectors that suffer direct financial losses (eg. members of agricultural, fisheries and tourism industries) and coastal property owners whose properties are affected by rising sea-levels.

Secondly, plaintiffs are certain to include environmental and other public interest groups, such as Friends of the Earth, Greenpeace and, in Australia, the Australian Conservation Foundation. Such groups are highly pro-active and well aware of the effectiveness of using legal mechanisms to

31 Australian Government, Department of Environment and Heritage, Australian Greenhouse Office, "Kyoto Protocol", at <<http://www.greenhouse.gov.au/international/kyoto>> viewed at 20 May 2006.

32 McCarthy (et al) (eds.), above n 22.

achieve environmental objectives. For example, in July of 2003, the London-based International Climate Justice Programme was launched. This is an alliance of 70 environmental organisations, lawyers, academics and individuals in 29 countries that seeks to hold those responsible for climate change based damage accountable and liable through the enforcement of existing laws. Similarly, in July of 2003, the Climate Action Network Australia launched the Australian Climate Justice Program with these same goals in mind.<sup>33</sup> Some environmental groups have already engaged in successful climate change litigation (see Chapters Two and Three).

Thirdly, governments are likely to be pro-active in bringing climate change actions in order to protect the economic, health and other interests of their citizens and residents. For example, current and past cases (see Chapters Two and Three) demonstrate that State governments in federal nations are prime candidates for bringing actions against their federal governments. National governments of nations seriously affected by global warming, such as those of island states threatened by sea-level rises, are also likely candidates for commencing actions.

### **Case study: environmental refugees**

Environmental refugees provide a good example of potential plaintiffs in climate change lawsuits. In the context of global warming, environmental refugees are likely to include those whose homes, property, livelihoods and possibly health are destroyed or seriously harmed by sea-level rises that are the result of climate change, such as people living on low-lying islands and river deltas.<sup>34</sup>

It is estimated that there are 14.9 million refugees and asylum seekers in the world and a further possible 22 million people who are "internally displaced".<sup>35</sup> "Displaced people" have traditionally been viewed within a refugee paradigm, as defined in the 1951 *Convention Relating to the Status of Refugees* and the 1967 *Protocol Relating to the Status of Refugees*.<sup>36</sup> Refugees are seen as people who have a "well founded fear of being persecuted" and are "outside of the country of nationality".<sup>37</sup> However, unlike "conventional"

33 See <<http://www.climatelaw.org>> and <<http://www.cana.net.au>>.

34 Such environmental refugees were the subject of a novel by M. Crichton, *State of Fear* (HarperCollins Publishers, London, 2004), which adopts a somewhat sceptical approach to the consensus view of climate change.

35 United Nations High Commissioner for Refugees (UNHCR), *Report of June 2002* (UNHCR, Geneva, 2002); US Committee for Refugees, *World Refugee Survey 2002* (Washington DC, 2002).

36 D.C. Bates, "Environmental Refugees? Classifying Human Migrations Caused by Environmental Change", *Population and Environment*, vol. 23, no. 5, May 2002, pp. 465-477.

37 M. Crock, "A Sanctuary Under Review: Where To From Here for Australia's Refugee and Humanitarian Program?", *UNSW Law Journal*, vol. 23, no. 3, 2000, pp. 246-287; H. Esmaeil and B. Wells, "The 'Temporary' Refugees: Australia's Legal Response to the Arrival of Iraqi and Afghan Boat People", *UNSW Law Journal*, vol. 23, no. 3, 2000, pp. 224-245; S. Taylor, "Do On-Shore Asylum Seekers Have Economic and Social Rights? Dealing with the Moral Contradiction of Liberal Democracy", *Melbourne Journal of International Law*, vol. 1, 2000, pp. 70-97.

refugees, environmental refugees are people who seek to migrate, or require substantial life-supporting aid, because of environmental change.<sup>38</sup> Typically, such people do not face a fear of persecution and are usually within their country of origin. However, environmental refugees are as disadvantaged as conventional refugees because their homes and ways of life have either been destroyed or substantially degraded.

According to some authorities, environmental refugees will become the largest group of displaced people in the world in the not too distant future due, in part, to global warming. For example, Janos Bogardi, of the United Nations University, puts the figure at 50 million people in the next five years.<sup>39</sup> The IPCC has warned that a faster than previously expected climate shift through anthropogenically caused global warming may displace tens of millions of people and lead to enormous social dislocation.<sup>40</sup> The people of the south Pacific, especially those living on low lying coral atoll islands, face particularly pressing problems due to sea level rises.

There are approximately 1,000 Pacific islands inhabited by Polynesian, Melanesian and Micronesian peoples, most of these islands falling within the UN definition of "small island states", being less than 10,000 square kilometres in area and inhabited by less than 500,000 people. The IPCC has pointed out that, with climate change, sea level rises and an increase in storm surges, there will be an increased level of contamination of already scarce freshwater supplies and a salination of agricultural land. Most of these small island states rely upon subsistence agriculture and fishing. The bleaching of coral reefs and the destruction of mangrove forests already threatens their fishing industries. Global warming will devastate the economies of nations such as Palau and the Federated States of Micronesia. Coral atoll reef islands, such as Kiribati, the Marshall Islands and Tuvalu, will be totally submerged through sea level rises if present trends continue unabated. Two uninhabited Kiribati islands, Tebua Tarawa and Abanuca, were submerged under water in 1999. As a result of these dire predictions, the Government of Tuvalu threatened, in September of 2002, to file a lawsuit at the International Court of Justice in The Hague against the United States and Australia.<sup>41</sup> Since 2003, the Government has been planning to evacuate its citizens, with these people now set to become environmental refugees. The World Bank, in its recent

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38 E. El-Hinnawi, *Environmental Refugees* (United Nations Environmental Program, Nairobi, 1985); S. O'Lear, "Migration and the Environment: A Review of Recent Literature", *Social Science Quarterly*, vol. 78, 1997, pp. 608-618.

39 N. Myers, *Environmental Exodus: An Emergent Crisis in the Global Arena* (Climate Institute, Washington DC, 1995) and "Environmental Refugees", *Population and Environment*, vol. 19, 1997, pp. 167-182; Janos Bogardi, BBC News, 11 October 2005 at <<http://news.bbc.co.uk/go/pr/fr/-/1/hi/sci/tech/4326666.stm>> viewed at 20 May 2006; R. Margesson, "Environmental Refugees", in L. Starke (ed.), *State of the World 2005* (W.W. Norton, New York, 2005), pp. 40-41.

40 See Working Group III, Intergovernmental Panel on Climate Change, *Climate Change 2001: Impacts, Adaptation and Vulnerability* (Cambridge University Press, Cambridge, 2001) available through: <<http://www.ipcc.ch/pub/online.htm>> viewed at 20 May 2006.

41 Kalinga Seneviratne, "Tuvalu Steps Up Threat to Sue Australia, U.S.", *Tuvalu News* (Tuvalu), 8 September 2002 <<http://www.tuvaluislands.com/news/archived/2002/2002-09-10.htm>> viewed at 12 May 2006.

report entitled *Not if But When*, says that the impact of climate change will be strongest in the low-lying atolls of the South Pacific.<sup>42</sup> Rising sea waters will flood 80 per cent of the land mass of Kiribati. Fiji will experience a 100 per cent increase in cyclone damage, up to 15 per cent decline in crop yields and an increase of dengue fever cases of between 20 and 30 per cent.

The first people to be officially evacuated because of sea level rises were the people of the Carteret Atolls in the Pacific, who were moved by the Papuan New Guinean regional Government to Bougainville, 100 kilometres away. In August 2005, a village population of 100 people in Lateu, Vanuatu, was moved to higher ground in the interior of Tegua in the northern province of Vanuatu.<sup>43</sup>

In April of 2004, a group of South Sea Islanders travelled to Australia for a "Climate Justice Tour" to bring their plight to the attention of the Australian Government. A Federal Minister responded on SBS television that their problem "has nothing to do with us". However, as will be seen from analyses in subsequent chapters, there are strong arguments that leading per capita greenhouse producing nations, such as the United States and Australia are, at least in part, causally and legally responsible for the plight of people such as the South Sea Islanders and others in similar situations, such as the estimated eight million people presently living on six major river deltas who are likely to face severe property and health damage from the effects of climate change.<sup>44</sup>

## **b. Defendants: governments & corporations**

Likely defendants to climate change suits are persons who can be shown to have helped cause, or to have materially contributed to, global warming. Generally, such persons are likely to fall into one of four key groups:

- (1) entities that burn fossil fuels in the course of providing a product or service (eg. electricity suppliers);
- (2) entities that supply fossil fuels (eg. oil companies);
- (3) entities that create products that burn fossil fuels or otherwise emit greenhouse gases (eg. car and fridge manufacturers); and
- (4) governments and agencies that fail to comply with environmental obligations.

42 See S. Bettencourt (et al), *Not If But When: Adapting to Natural Hazards in the Pacific Islands Regions: A Policy note* (The World Bank, Washington DC, 2006). On the climatic problems of "small island states" see World Health Organization, *Synthesis Workshop on Climate Variability, Climate Change and Health in Small-Island States* (World Health Organization, Geneva, 2004).

43 J. Vidal, "Pacific Atlantis: First Climate Change Refugees", *Guardian*, 25 November 2005 at <<http://www.guardian.co.uk/print/0,3858,5341360-110970,00.html>> viewed at 20 May 2006.

44 J. Hecht, "Losing the Ground Beneath Their Feet", *New Scientist*, 18 February 2006, pp. 8-9. River deltas, such as the Bengal delta in Bangladesh, the Yangtze delta in China, the Mekong delta in Vietnam and the Godavari delta in India, are subsiding due to the pumping of water and oil as well as the fact that sediments are not reaching them because of upstream dams. They are highly vulnerable to the added effects of global climatic change.

Another group of organisations that could be added to this list is entities that engage in activities that reduce the size of carbon sinks. Generally, a carbon sink is something that naturally removes carbon from the atmosphere, such as an area of vegetation or an ocean. Logging companies are a prime example of such a group as deforestation reduces the size of forests, enhancing the greenhouse effect by causing more carbon dioxide to remain in the atmosphere than would otherwise be the case. Whilst the relevance of such organisations as potential defendants should not be overlooked, most of the analyses regarding possible legal actions and scientific evidence throughout this book focus on greenhouse gas emitting activities but are, in a majority of cases, equally relevant to “carbon sink reducing” activities. Whilst the parallels in many cases are clear, the relevance of such actions and evidence in relation to carbon sink reducing activities would require separate review and, as such, generally remains outside the scope of this book.

Significantly, the case of *Friends of the Earth Inc et al v Peter Watson et al*<sup>45</sup> (discussed in Chapter Two) indicates that organisations and governments involved in the financing of corporations in high-impact industries may also be the target of climate change plaintiffs.

Of course, it is important to keep in mind that many individuals and organisations in industrialised nations produce or emit greenhouse gases (for example, individuals emit greenhouse gases in the form of exhaust fumes from their motor vehicles and when using aerosol sprays containing chloro-fluorocarbons). However, it is only organisations that emit, or enable the emission of, significant quantities of greenhouse gases, such that it can be said that they have caused, or materially contributed to, global warming, that are potential targets for plaintiffs.

Governments at all levels are potentially liable to prosecution, primarily in relation to actions that fail to fulfill their legal duties, under either international or domestic laws, to protect the environment: for example, by failing to prevent polluting activities within their jurisdiction or to take into consideration environmental impacts when making planning decisions. Due to the separation of powers, governments generally are not open to prosecution, particularly in relation to negligence, on the grounds that their policies (which are often dictated by political, economic and social factors) encourage or enable high levels of greenhouse gas emissions. Courts have repeatedly indicated that the merits of such policies is something to be resolved by voters through democratic processes rather than by the courts. For the most part, national governments culpable of environmental neglect are likely to be most vulnerable. In particular, the US and Australian Governments have been, and remain, targets for environmental litigants because of their refusal to sign the Kyoto Protocol and their poor environmental records. This leads to the issue of whether nations that have signed the Kyoto Protocol are less vulnerable to climate change actions. The answer to this question is necessarily complex.

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45 US District Court, Northern District of California, San Francisco Division, 26 August 2002, Civ No. 02-4106 (JSW). See documents at <<http://www.climatelawsuit.org/>> viewed at 20 May 2006.

Briefly, however, the Kyoto Protocol is, generally speaking, considered by the international community as the appropriate response to global warming. As such, Kyoto Protocol-nations that meet their greenhouse gas emission reduction targets under the Protocol arguably have a strong defence to climate change suits based on the fact that they are doing all that the international community requires of them (although, of course, the validity of any such defence would depend on the applicable law and specific cause of action). Obviously, Kyoto-Protocol nations that fail to meet their targets would not have the benefit of such a defence. However, regardless of whether nations meet Kyoto Protocol requirements, it is also possible that there may be abrupt climate changes and unexpected climatic damage that could not have been prevented by nations implementing the Kyoto Protocol. In other words, the level of greenhouse gas reductions required by the Kyoto Protocol may be insufficient to prevent substantial climatic-based harm. In this context, all polluting nations would appear to be vulnerable, irrespective of whether they have signed the Kyoto Protocol or are meeting its requirements.

To demonstrate why public interest groups are likely to target the US and Australian Governments and organisations within the United States and Australia, key environmental criticisms of those Governments are summarised below.

### **Case Study: United States**

As discussed earlier, the United States has not signed the Kyoto Protocol and has effectively adopted a business-as-usual approach to global warming. At Montreal, after initially abandoning talks, the United States intended to prepare a post-Kyoto position and eventually agreed to participate in future talks but without making any commitment to action. The Bush Administration has essentially adopted a position of global warming scepticism or agnosticism, its position being that there are numerous scientific uncertainties involved in climate models and that further scientific research is needed before carbon dioxide emission reductions, which may harm America's economic growth, are made mandatory. In principle, the Bush Administration is not opposed to carbon dioxide emission reductions arising from technological innovations that are economically efficient. In practice, however, there is little evidence that this principle is followed. This attitude contrasts with the statement made in 2003 by British Prime Minister Tony Blair who has been quoted as saying that "there can be no genuine security if the planet is ravaged by climate change".<sup>46</sup> The US position contrasts even more sharply with the view expressed by French President Jacques Chirac, made at the World Summit on Sustainable Development in Johannesburg in 2002, that "our house is burning down and

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46 Cited from J. Houghton, "Global Warming is Now a Weapon of Mass Destruction", *The Guardian* (UK), 28 July 2003 at <<http://www.guardian.co.uk/climatechange/story/0,,1007291,00.html>> viewed at 20 May 2006. Nevertheless, Blair has reportedly made comments that could conflict with this viewpoint: see, eg., D. Shearman, "One Tiny Step for Humanity, With a Big Limp", *The Independent Weekly* (Adelaide), 13-19 February 2005, p. 9 at <<http://www.onlineopinion.com.au/view.asp?article=3085>> viewed at 20 May 2006.

we're blind to it. Nature, mutilated and overexploited, can no longer regenerate and we refuse to admit it".<sup>47</sup>

A number of organisations and academic writers have written about, and commented on, what they refer to as the Bush Administration's "assault on the environment", a reference to its alleged winding back of environmental laws and protections, increase in development projects on public lands and limitation of public participation in agency decisions.<sup>48</sup> For example, a Natural Resources Defense Council study, entitled *Rewriting the Rules: The Bush Administration's Assault on the Environment* (2002),<sup>49</sup> has documented what it claims to be a coordinated attempt by the Bush Administration to relax environmental regulations for the automobile, oil, coal, mining, logging and chemical industries – each of which contribute significantly to greenhouse gas emissions. Changes to the *Clean Air Act* are claimed to have created loopholes which enable some of America's oldest power plants and refineries to avoid the need to install modern pollution control equipment when upgrading or expanding their facilities.<sup>50</sup>

Governmental approaches that are perceived by public interest groups and others as avoiding climate change issues serve to increase the resolve of plaintiffs to use legal mechanisms to require the US Government to address global warming issues.

### **Case Study: Australia**

Studies show that Australia possibly has one of the worst environmental records of any developed country.<sup>51</sup> Australia is the leading per capita emitter of greenhouse gases with 6.8 tonnes of carbon equivalent per capita. The United States ranks second at 6.6 tonnes of carbon equivalent per capita. In contrast, India is the 25<sup>th</sup> major per capita emitter with 0.5 tonnes of carbon equivalent per capita.<sup>52</sup> The United States has the highest portion of the world's greenhouse gas emissions at 20.6 per cent, while Australia ranks 17<sup>th</sup> at 1.4 per cent.<sup>53</sup> Australia still permits the dumping of highly toxic heavy metal wastes, chlorine and other chemicals into its ecologically sensitive

47 President Jacques Chirac, Statement at the World Summit on Sustainable Development, Johannesburg, South Africa, 2 September 2002.

48 See, eg., the Natural Resources Defense Council "Bush Record" at <<http://www.nrdc.org/bushrecord>>, Sierra Club "W Watch" available through <<http://www.sierraclub.org>> and the Environmental Integrity Project at <<http://www.environmentalintegrity.org>> all viewed at 20 May 2006; R. Smith, "Death Through Selfishness and Failure of Imagination", *British Medical Journal*, vol. 322, 2001, p. 690.

49 Available at <<http://www.nrdc.org/bushrecord>> viewed at 20 May 2006. See also OMB Watch <<http://www.ombwatch.org>> viewed at 20 May 2006.

50 Ibid.

51 S. Mann, "Australia – Global Sociopath", *Alternative Law Journal*, vol. 26, no. 1, February 2001, pp. 3-6, 21.

52 Ibid.

53 See Figure 1 and 6 in K. Baumert and J. Pershing (et al), *Climate Data: Insights and Observations* (prepared for the Pew Center on Global Climate Change, December 2004); C. Hamilton, *Running from the Storm: The Development of Climate Change Policy in Australia* (University of New South Wales Press, Sydney, 2001), pp. 12-30; H. Turton, *Greenhouse Gas Emissions in Industrialized Countries: Where Does Australia Stand?* (The Australia Institute, Discussion Paper No. 66, June 2004).

waters. It has the Organisation for Economic Co-operation and Development's (OECD's) highest per capita production of municipal waste – 687 kilograms per person per year compared with the OECD average of 513 kilograms.<sup>54</sup> Non-renewable energy consumption is also higher than the OECD average.<sup>55</sup>

As evidenced by these statistics, Australia is, on a per capita basis, a major contributor to both greenhouse gas emissions and global warming, due in large part to the fact that its primary export is coal. When burned, coal emits more carbon dioxide per joule of energy generated than any other fossil fuel. Coal emissions are also a major cause of acid rain which has decimated forests across the world and, consequently, reduced the number of trees acting as “carbon sinks”, or users of carbon. As such, the burning of coal makes a significant indirect contribution to global warming. Large numbers of Australian corporations and industries are viewed by many as having generally failed to treat the Kyoto Protocol seriously<sup>56</sup> and conveniently regarded it as a technically flawed threat to Australia's economic growth.<sup>57</sup> Such organisations and industries have often defended their positions by relying on global warming sceptic arguments which call into question the consensus view of global climatic change.<sup>58</sup> Such cases of environmental neglect are likely to continue to motivate climate change plaintiffs to target polluting organisations within Australia.

### 3. The Broader Picture Behind Climate Change: Poor Global Health

The global warming debate is taking place in the context of a broader dialogue regarding the decline of the world's ecosystems (ie. the planet's ecological health). Many issues regarding climate change actions are likely to be concerned with, either directly or indirectly, this broader environmental issue. As such, it is useful, and in many cases important, for parties involved in climate change litigation to have a background understanding of issues regarding the current ecological plight of the planet. At the same time, however, it is equally important to be aware that causes and effects regarding the decline in the planet's ecological health are not all related to global warming. Whilst global warming is one of the most important environmental impact agents on the planet's declining ecological health, there are others, such as over population and urbanisation. By way of background to climate change issues, the paragraphs below provide an overview in broad brush strokes of the emerging scientific consensus about the state of the planet's environment.

54 Mann, above n 51. All statistics have been quoted from this source.

55 Ibid.

56 See, eg, A. Trainson and F. Chong, “Kyoto's Just Hot Air For Our Corporations”, *The Australian*, 17 February 2005, p. 25.

57 See, eg, A. Wood, “No Future in Kyoto Protocol”, *The Australian*, 2 March 2004, p. 13.

58 See, eg, G.W. Paltridge, “The Politicised Science of Climate Change”, *Quadrant*, October 2004, pp. 14-18; M. Steyn, “Climate Change Myth”, *The Australian*, 11 January 2006, p.12.

### a. Declining ecological health of the planet

A majority of the world's leading scientists and environmentalists agree that the planet is in a perilous ecological state. A minority of scientists and other persons, however, reject this position. It is relevant to note that members of the majority group often have a "Malthusian" philosophical outlook – that is, that natural resources are finite and that humankind will not be able to overcome such limitations with technological solutions and, as such, will need to limit its demands on the world's natural resources. In contrast, members of the minority group often have a "Cornucopian" outlook – that is, that natural resources are infinite and, as such, there are no limits to economic growth or the "sink" or absorption capabilities of ecological systems.<sup>59</sup>

Scientists have warned that humanity has perhaps one or two generations to act to avoid global ecological catastrophe. In 1992, the Royal Society of London and the US National Academy of Sciences issued a joint statement, entitled *Population Growth, Resource Consumption, and a Sustainable World*,<sup>60</sup> in which they expressed their concern that a combination of population growth and unsustainable use of resources by humans may irreversibly damage the planet's capacity to sustain life. The statement recognised that science and technology are not magical answers to humanity's plight, stating it "is not prudent to rely on science and technology alone to solve problems created by rapid population growth, wasteful resource consumption, and harmful human practices".<sup>61</sup> In the same year, the Union of Concerned Scientists issued their own statement, entitled *World Scientists' Warning to Humanity*, which was signed by over 1,700 scientists with a majority of the Nobel laureates (over various years) in the sciences also signing.<sup>62</sup> This statement also emphasised that human economic expansion is disrupting ecological systems to such an extent through deforestation, species loss and climate change that an unpredictable collapse of vital ecological systems could occur. Humanity is quickly approaching many of the planet's limits and failure to achieve ecological sustainability will result in "spirals of

59 As a point of interest, the Global Commons Institute (GCI) has found from an analysis of data nearly a 100 per cent correlation between world GDP growth and the emission of greenhouse gases through the use of hydrocarbon fuels. See A. Simms, *Ecological Debt: The Health of the Planet and the Wealth of Nations* (Pluto Press, London, 2005).

60 Royal Society of London and US National Academy of Sciences, Joint Statement, *Population Growth, Resource Consumption, and a Sustainable World* (1992) at <<http://www.dicoff.org/page75.htm>> viewed at 20 May 2006.

61 *Ibid.* The medium series world population projections released by the United Nations Population Division predict that world population will increase from just under 6.5 billion in 2005 to 9.1 billion by 2050, an increase equivalent to the current populations of India and China combined. The high series projection is 10.6 billion by 2050. On the medium series projection, there will be 7 billion in 2012, 8 billion in 2027 and 9 billion in 2048. Compare this to the world population of 1804 of 1 billion, 1927 of 2 billion, 1960 of 3 billion, 1974 of 4 billion, 1987 of 5 billion and 1999 of 6 billion. See United Nations Population Division, *World Population Prospects: The 2004 Revision Highlights* (United Nations, New York, 2005).

62 Union of Concerned Scientists, *World Scientists' Warning to Humanity*, 18 November 1992 at <<http://www.ucsusa.org/ucs/about/1992-world-scientists-warning-to-humanity.html>> viewed at 20 May 2006.

environmental decline, poverty and unrest, leading to social, economic and environmental collapse".<sup>63</sup>

This theme of approaching environmental catastrophe is also found in a number of other scientific statements. The *Joint Statement of 58 of the World's Scientific Academies* was a declaration on the state of the environment made at the New Delhi Conference of 1993 and was signed by 58 of the world's scientific academies.<sup>64</sup> It stated that "[h]umanity is approaching a crisis point with respect to interlocking issues of population, environment and development. With each year's delay the problems become more acute".<sup>65</sup> The Inter-Academy Panel of International Issues was formed at that conference.

In 1997, the Kyoto conference on global warming took place which led to the Kyoto Protocol.<sup>66</sup> In the same year a resolution by the Joint National Academy of Scientists and Royal Society entitled, *Towards Sustainable Consumption*, was made.<sup>67</sup> The Union of Concerned Scientists also signed a statement, entitled *World Scientists' Call for Action*, in that year.<sup>68</sup> This statement of concern about the world's environment was signed by 1,500 scientists from 63 countries, including 110 Nobel laureates and 60 US National Medal of Science winners. In May of 2000, the Statement of the World's Scientific Academies, entitled *Transition to Sustainability in the 21<sup>st</sup> Century: The Contribution of Science and Technology*, was made.<sup>69</sup> It stated that "...if current trends in population growth, consumption of energy and materials, and environmental degradation persist, many human needs will not be met and the numbers of hungry and poor will increase".<sup>70</sup>

Common to all of these statements is not only a desire for science and technology to be used to achieve ecological sustainability, but also a realistic recognition that science and technology alone cannot solve the problem of the environmental crisis. They acknowledge that a new relationship between humans and nature must be forged.

A number of important studies of the global health of the planet have accompanied these statements of scientific opinion.

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63 Ibid.

64 *Joint Statement by 58 of the World's Scientific Academies*, US National Academy of Sciences at <<http://dicoff.org/page75.htm>> viewed at 20 May 2006.

65 Ibid.

66 Available at <<http://unfccc.int/resource/docs/convkp/kpeng.html>> viewed at 20 May 2006.

67 *Joint National Academy of Scientists and Royal Society Resolution, Towards Sustainable Consumption* (1997), US National Academy of Sciences at <<http://www.royalsoc.ac.uk/document.asp?tip=0&ID=1907>> viewed at 20 May 2006.

68 *World Scientists' Call for Action*, Union of Concerned Scientists, December 1997 at <<http://go.uesusa.org/ues/about/page.cfm?pageID=1007>> viewed at 20 May 2006.

69 *Inter-Academy Panel, May 2000, Transition to Sustainability in the 21st Century: The Contribution of Science and Technology* at <<http://www.interacademies.net/CMS/Abou/3143/3552.aspx>> viewed at 20 May 2006.

70 Ibid.

### ***i. Report of UN, World Bank & World Resources Institute***

The *Guide to World Resources, 2000-2001: People and Ecosystems: The Fraying Web of Life*<sup>71</sup> was a joint venture of the United Nations Development Program, the United Nations Environment Program, World Bank and World Resources Institute. A group of 197 scientists developed a model called the Pilot Analysis of Global Ecosystems (PAGE). The model was called a "Pilot" because it was recognised that further research was needed to fill existing gaps in knowledge about global ecosystems. An ecosystem is a biological community of interacting organisms and their physical environment. Ecosystems vary greatly in size: for example, it could include the Amazon rainforest or a pasture in a farm. Ecosystems are important to the maintenance of life and health because organisms need other organisms for things such as food and reproduction (eg. the pollination of flowers by bees ensures the reproduction of those flowers). Like animals and other living organisms, human beings depend upon ecosystems for survival and especially for the provision of food resources.

PAGE studied five major classes of ecosystems: agro-ecosystems, coastal regions, forests, freshwater systems and grasslands. The health of these ecosystems was assessed on the basis of the quality and quantity of resource output and biological factors such as water quality, biodiversity, soil quality and other factors. Ecosystem health was then graded on the basis of scorecards using the following criteria where applicable: water quality and quantity, food/fibre production, carbon storage, biodiversity, shoreline protection, recreation and wood fuel production.

The report concluded that all of the world's major ecosystems are in decline and the effects of these declines are affecting all humans. Current patterns of consumption and resource use will worsen the situation. The earth's capacity to supply ecological "goods and services" is in decline whilst human degradation of these systems is occurring at an accelerating pace. Key findings and scores are summarised below.

- *Agro-ecosystems*: Within the last fifty years, two thirds of the world's agricultural land has been degraded by salinisation, erosion, nutrient depletion, compaction, biological degradation and industrial and urban pollution. Forty per cent of agricultural land has been strongly degraded. Decreasing food production, water quality, water quantity and biodiversity was observed, with mixed results on carbon storage.
- *Coastal ecosystems*: Decreasing biodiversity; mixed results on water quality; decreasing food production; decreasing shoreline protection; insufficient data on recreation.
- *Forest ecosystems*: Increasing fibre production (through logging and deforestation); decreasing water quality, water quantity, biodiversity and carbon storage; insufficient data on wood fuel production.

71 *Guide to World Resources, 2000-2001: People and Ecosystems: The Fraying Web of Life* (World Resources Institute, April 2000) at <[http://pubs.wri.org/pubs\\_descripti on.cfm?PubID=3027](http://pubs.wri.org/pubs_descripti on.cfm?PubID=3027)> viewed at 20 May 2006.

- *Freshwater ecosystems*: Mixed results for food production; decreasing water quality, water quantity and biodiversity.
- *Grassland ecosystems*: Decreasing food production, biodiversity, carbon storage and recreation.

Despite these poor results, the report concludes that there is still time for ecosystems to recover if humanity manages resources in an ecologically sustainable manner.

## **ii. Report of UN Environment Programme**

The conclusions of the *Guide to World Resources* are generally confirmed by the more recent *Global Environmental Outlook 3* (2002)<sup>72</sup> (GEO), published by the United Nations Environment Programme. This report is the third of three reports, the first published in 1997 and the second in 1999, each of which provides a comprehensive account of the state of the Earth's environment. However, perhaps more so than in any of the other reports mentioned above, the GEO reports focus on the disparity between impoverished and affluent nations with respect to the issue of dealing with environmental degradation and achieving ecological sustainability. Affluent nations have access to technological and scientific resources in dealing with environmental problems. Impoverished peoples lack such resources and typically must draw upon their ecological resource bases for survival. The most affluent one-fifth of the world's population accounts for 90 per cent of the world's personal consumption. The poorest one-fifth of the world lives on less than \$US1.00 per day. The report states that the poor are especially vulnerable to environmental change because they have, relative to the affluent, lower coping capacities owing to the fact that they have fewer resources to aid them in dealing with environmental change. As discussed in later chapters, this lack of ability to cope with the consequences of global warming and environmental decline is likely to be a major source of ill-health for the poor of the world<sup>73</sup> and, as such, has the potential to lead to legal claims in the context of climate change.

GEO considers what may happen to the environment over the next 30 years. It does this by considering four different scenarios based on different policy approaches. These can generally be referred to as markets first, policy first, security first and sustainability first scenarios. The markets first scenario entails market mechanisms, with increasing resource demands, being used to enhance wealth and, in doing so, enable people to afford to resolve social and environmental problems. The policy first scenario involves governments devising policies to find appropriate

72 United Nations Environment Programme, *Global Environmental Outlook 3: Past, Present and Future Perspectives* (Earthscan Publications Ltd., London, 2002).

73 Ibid, Chapter 3, "Human Vulnerability to Environmental Change"; T.F. Homer-Dixon, *Environment, Scarcity and Violence* (Princeton University Press, Princeton, 1999); A.J. McMichael, *Human Frontiers, Environments and Disease: Past Patterns, Uncertain Futures* (Cambridge University Press, Cambridge, 2001); C.J.L. Murray and A.D. Lopez, *The Global Burden of Disease* (Harvard University Press, Cambridge MA, 1996); UNEP, *Assessing Human Vulnerability Due to Environmental Change: Concepts, Issues, Methods and Case Studies* (UNEP/DEWA/TR, Nairobi, 2000).

balances between economic development and environmental protection. The security first scenario involves a world of disparities where inequality and conflict prevail. Socio-economic and environmental stresses give rise to protest and counteraction, resulting in the more powerful and wealthy focusing on self-protection. The sustainability first scenario assumes the emergence of a new environment and development paradigm in response to the challenge of sustainability, supported by new, more equitable values and institutions. In general, under business-as-usual scenarios, typically represented by placing markets first, carbon dioxide emissions would increase, biodiversity decline would continue, soil depletion would generally increase, freshwater depletion would increase, transport and energy efficiency would remain constant, forest cover would decrease, marine and coastal pollution would increase and poverty and disparity would increase. The report generally concluded that the markets first and security first scenarios would result in the most pessimistic outcomes, whilst the policy first scenario would result in a better outcome. The sustainability first scenario, however, offers the most positive outlook for the environment.

### ***iii. Assessment commissioned by UN Secretary-General***

The most comprehensive global inventory of the state of planetary ecosystems is the *Millennium Ecosystem Assessment Synthesis Report* (March 2005) (MEA Report).<sup>74</sup> This assessment was called for in 2000 by UN Secretary-General, Kofi Annan, in his report to the UN General Assembly entitled *We the Peoples: The Role of the United Nations in the 21<sup>st</sup> Century*.<sup>75</sup> The objective of the MEA Report was

to assess the consequences of ecosystem change for human well-being and to establish the scientific basis for actions needed to enhance the conservation and sustainable use of ecosystems and their contributions to human well-being.<sup>76</sup>

As such, the report focussed on the linkages between ecosystem change and human well-being. Generally, human well-being is what scientists call "ecological health". In the report, however, human well-being is viewed as including a range of factors in addition to those that would fall within the scientific meaning of ecological health. In the report, "health" is just one component of human well-being. Other components include the basic materials of a good life, such as adequate food, shelter and clothing and access to goods, good social relationships, personal security, protection from natural and human-caused disasters and freedom of choice and action. The main conclusions of the MEA Report regarding the state of the Earth's ecosystems are summarised below.

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74 Millennium Ecosystem Assessment, *Millennium Ecosystem Assessment Synthesis Report*, at <<http://www.millenniumassessment.org/en/Products.EHWB.aspx>> viewed at 20 May 2006.

75 Secretary-General Kofi Annan, *We the Peoples: The Role of the United Nations in the 21<sup>st</sup> Century* (United Nations, New York, 2000).

76 Millennium Ecosystem Assessment, above n 74, p.5.

Fifteen of the 24 ecosystems examined are degraded or used unsustainably. Ecosystems have changed more rapidly in the last 50 years than at any other comparable period of human history. These changes have arisen from the human need for food, fuel and materials and has resulted "in a substantial and largely irreversible loss in the diversity of life on earth".<sup>77</sup> There is as yet incomplete evidence that these human-induced changes are increasing the risk of non-linear changes, in ecosystems producing abrupt, accelerating and often potentially irreversible changes.<sup>78</sup> The report provides examples of such non-linear changes including emergent diseases, abrupt changes in water quality, the creation of coastal "dead zones", the collapse of fisheries and abrupt climate change.<sup>79</sup>

The report states that the deleterious effects of the degradation of ecosystem services are borne disproportionately by the poor of the world, "contributing to growing inequities and disparities across groups of people, and are sometimes the principle factor causing poverty and social conflict".<sup>80</sup> Although ecosystem changes arising from increased food production have aided many hungry and poor people, these changes have harmed other communities. Global population growth will level off by 2050<sup>81</sup> but there is likely to be a three to sixfold increase in global GDP over the same period "which is unsustainable in many cases".<sup>82</sup>

The report found that, over the period studied, there has been a substantial production increase in the ecosystem services of crops, livestock, and aquaculture and that global climate regulation has been enhanced via a net source of carbon sequestration since the mid-20<sup>th</sup> century.<sup>83</sup> The report found that other categories have had mixed positive and negative effects: timber has seen forest loss in some regions, but growth in others; cotton, hemp and silk have seen declining production in some fibres but growth in others; water regulation, disease regulation and recreation have been enhanced in some regions, but degraded in others and ecotourism has become more accessible in some areas but degraded in others. However, one of the most concerning findings of the report is that a vast majority of ecosystem providing services have been degraded.

The report found that capture fisheries have experienced declining production due to overharvesting and at least one quarter of marine fish stocks are now overharvested. The amount of fish harvested increased until the 1980s but is now declining because of shortages. Overfishing, changes to habitats and the withdrawal of fresh water have also led to a decline of inland fisheries' stocks. Wild foods and wood fuel have also experienced declining production. Genetic resources have declined through extinction loss and crop genetic resource loss. Overharvesting and extinction have also reduced biochemicals, natural medicines and natural pharmaceuticals. Freshwater resources have

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77 Ibid p.16.

78 Ibid p.17.

79 Ibid.

80 Ibid.

81 Ibid.

82 Ibid p.17.

83 Ibid p.41, Table 1.

declined as has the ability of the atmosphere to cleanse itself. There has been a preponderance of negative impacts at the regional and local level with respect to climate regulation. Erosion regulation has declined through increased soil degradation. Ecosystem services such as water purification and waste treatment, pest regulation, pollination and natural hazard regulation, have all declined. Cultural services including spiritual and religious values have declined in "sacred groves" as have aesthetic values through a decline in the quantity and quality of natural lands.<sup>84</sup>

Human activities are increasing the use and depletion of ecological resources in an unsustainable fashion that is resulting in a deterioration of basic ecological services that form the "fabric of life".<sup>85</sup> The World Health Organisation, in its contribution to the MEA Report, concluded that approximately 60 per cent of the benefits that natural ecosystems provide – such as fresh water, clean air and a relatively stable climate – are being degraded or not being used sustainably.<sup>86</sup> Major problems include the provision of safe drinking water to the world's poor, adequate nutrition and the ill-health effects of solid fuel dependency. Climate change may have some benefits to human health (such as a reduced cold weather mortality) but the World Health Organisation believes that most effects will be negative. There will be direct health effects, such as increased mortality from heat waves and also indirect health effects through climate-induced changes in ecosystems which will affect the availability of food, water and energy supplies. There will be an impact upon human health by changes in these factors which influence the distribution of infectious diseases (these issues are addressed in Chapter Five).

#### **iv. Other works**

An important PhD thesis by Colin Butler of the Australian National University, entitled *Inequality and Sustainability* (2002),<sup>87</sup> argues that global civilisation and population health are threatened by a number of factors, including adverse environmental change and excessive inequality. Butler constructed a weighted time series index of global environmental change (IGEC) for the period of 1960-1997. The index used nine categories of global time series environmental data with a scale such that 100 per cent represents the level of each category in nature prior to human-caused change and 0

84 Ibid.

85 Ibid.

86 World Health Organisation (WHO)/Millennium Ecosystem Assessment, *Ecosystems and Human Well-Being: Health Synthesis* (December 2005) available through <<http://www.who.int/globalchange/ecosystems/ecosystems05/en/>> viewed at 20 May 2006.

87 Colin Butler, *Inequality and Sustainability*, PhD thesis, the Australian National University, February 2002 at <<http://thesis.anu.edu.au/public/adt-ANU20030324.171924/index.html>> viewed at 20 May 2006. See also Worldwatch Institute, *State of the World 2005: Redefining Global Security* (WW Norton, New York, 2005) where a number of contributors, including Mikhail Gorbachev, Chairman of Green Cross International, argue that the major threat to global civilisation is destabilisation of human society through environmental degradation. Narrow national security concerns conceptualised around military might need to be replaced by sustainability concerns.

represents a critical point. Butler found that the index fell from 82 per cent in 1960 to 55 per cent in 1997 and he argues at length that further declines in the index will occur in the 21<sup>st</sup> century. The decline in the IGEC strongly correlates major macro-environmental changes. He argues that, with flawed, unsustainable social responses to scarcity issues, the continuation of civilisation is threatened. Civilisation failure and social dislocation caused through global environmental change will have extremely serious adverse health effects.

### **b. Linking ecological health to human health**

Ecological health impacts heavily upon human health. As a result of the decline in the planet's ecological health, damage to human health is likely to be a major consequence of global warming (as outlined in Chapter Five). As such, an understanding of the links between the two is central to obtaining an appreciation of the human health implications of global warming.

Scientific materials regarding the decline in ecosystems and global warming are complex. Viewing the materials within a philosophical framework (ie. a comprehensive theoretical framework in which to understand the causes, effects and interactions of damage to ecosystems) assists in understanding the mechanisms by which damage to human health is likely to occur as a result of this decline and, in a legal context, in establishing causal chains leading to harm. The philosophical framework within which the scientific evidence best fits is what has been called an "ecological health paradigm", in which human health is viewed as an ecological concept (ie. as something that is affected by its physical surroundings) and, in this case, as something which is intimately connected with the health of the environment. Such a paradigm sees complex interactions and feedbacks between human activities, human health and the state of the environment. Viewing the scientific evidence within this paradigm assists in understanding the mechanisms by which damage to human health is likely to occur as it is based on the premise that determinants of human health depend upon fundamental social and ecological realities, such as access to infrastructure, clean water, sanitation and prevention of heat stress. In the context of climate change litigation, this is important as, in establishing a chain of causation, there will be a wide range of intervening variables as well as complex interactions and feedbacks between those variables.

The ecological health paradigm builds upon the World Health Organization's 1948 definition of health as "a state of complete physical, mental and social well-being, not merely the absence of disease or infirmity".<sup>88</sup> This view of health rejects a narrow reductionistic (solely physical) biomedical model which sees health as merely the absence of "disease". This reductionist position has difficulty understanding social and psychological roots of many illnesses (eg. obesity) and typically looks for chemical or mechanical solutions to illnesses, often through the elimination of symptoms

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<sup>88</sup> See D. Shearman and G. Sauer-Thompson, *Green or Gone? Health, Ecology, Plagues, Greed and Our Future*, (Wakefield Press, Adelaide, 1997), p.11.

(eg. “stomach stapling” to deal with overeating rather than a lifestyle approach encompassing careful diet and exercise). The ecological health paradigm attempts to understand human health in the broadest possible context, taking into consideration physico-chemical, biological, psychological and socio-economic-political factors<sup>89</sup>. As has already been seen in the earlier discussion regarding the *Millennium Ecosystem Assessment Report* (MEA Report), it is not highly controversial today to suppose that human health and well-being are dependent upon the health of ecosystems. However, the present authors differ from the MEA Report in that they believe that “human health” can generally be used interchangeably with “human well-being”, whereas the MEA Report operates with a more restricted definition of health, although it does recognise the legitimacy of the wider use of the term as a common practice in the health community. As Dr. Halfdan Mahler, a former Director-General at the World Health Organization, said:

We are now witnessing that the term physical well-being means much more than the biology of the human body: it includes a safe environment and the responsibility for our physical surroundings on the planet as a whole.<sup>90</sup>

However, ignoring these differences in definition, the important issue is the recognition that the determinants of human health depend upon fundamental social and ecological realities. This is of central importance in a legal context as it assists plaintiffs in establishing chains of causation; in particular, it will help them to demonstrate that global warming impacts on ecosystems which, in turn, impact upon human health. As such, the ecological health paradigm offers a more detailed understanding and conceptualisation of human health problems as it addresses a wider range of factors impacting on human health than other paradigms which, for example, only look to the “biology of the human body” for explanations. The ecological health paradigm is particularly concerned with *interactions* between physical, social and cultural environments.

The paragraphs below look at two ecological services to illustrate the ecological health paradigm; firstly, water quality and quantity and, secondly, biodiversity. Ecological health implications of global declines in water quality and quantity and threats to biodiversity are severe. It is important to remember, however, that neither of these declines or threats is caused solely by global climate change. Rather, they are influenced and exacerbated by a multitude of environmental factors of which global warming is one.

The World Water Council estimates that 1.4 billion people in the world do not have access to safe drinking water, 2.6 billion people lack satisfactory sanitation and water-associated infectious diseases claim 3.2 million lives annually, which is approximately 6 per cent of all human deaths.<sup>91</sup> World

89 Ibid. See further: S. Boyden, *The Biology of Civilisation: Understanding Human Culture as a Force in Nature* (University of New South Wales Press, Sydney, 2004).

90 H. Mahler, Keynote address to the Second International Conference on Health Promotion, Adelaide, 1988. Cited from Shearman and Sauer-Thompson, above n 88, p.13.

91 World Water Council, “Water Crisis” at <<http://www.worldwatercouncil.org/index.php?id=25>> viewed at 20 May 2006 and World Health Organisation (WHO)/Millennium

water consumption is rising at approximately twice the rate of population growth.<sup>92</sup> At the Third World Water Forum held in Kyoto in March of 2003, William Cosgrove, Vice-President of the World Water Council, is reported as having said that “[t]he world is in a water crisis that will grow more acute and devastating in coming years unless governments start giving higher priority to water in their development and investment plans”.<sup>93</sup>

Water is of unquestionable importance for human health as consumption of clean uncontaminated water is necessary for the maintenance of human life. However, water is also important for personal hygiene as washing is able to control a number of diseases. For example, diarrhoeal disease is a leading cause of death in developing countries with about 2.2 million people dying from it each year. Ninety per cent of the deaths are those of children. Most deaths are due to a single type of bacteria, *Shigella*, which can be controlled by improvements in water supply, sanitation and hygiene. Merely washing one’s hands with soap and water reduces the incidence of *Shigella* and other forms of diarrhoea by almost 35 per cent.<sup>94</sup> A large number of water-based diseases, such as dysentery and cholera, can be eliminated, diminished or prevented by water supply improvements.<sup>95</sup> Degradation of water resources will, at least in developing countries, directly contribute to the spread of disease. The examples discussed briefly here demonstrate how a decline in the ecological services of water quantity and quality directly cause damage to human health.

Desertification and droughts are already a threat to human health in arid, semi-arid and dry sub-humid areas.<sup>96</sup> Climate change is a key cause of such land degradation although there are, of course, other causes – such as overcropping as a result of farmers growing cash crops rather than engaging in subsistence farming. Climate change may alter rainfall patterns causing a rise in droughts and, in turn, increased desertification. Desertification in turn results in declining agricultural productivity, a fall in individual income levels, poverty and, consequently, a decline in health. Poverty is directly linked to ill-health through obvious causal pathways; for example, a lack of financial resources leads to a lack of economic access to health care and medicines which generally cost money. In general, countries with the lowest GDP per capita have the highest mortality rates.<sup>97</sup> In developing regions, especially

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Ecosystem Assessment, *Ecosystems and Human Well-Being: Health Synthesis* (December 2005) available through <<http://www.who.int/globalchange/ecosystems/ecosystems05/en>> viewed at 20 May 2006.

92 Ibid.

93 “World Forum Views Water as a Life and Death Issue”, *Environment News Service*, 21 March 2003 at <<http://www.ens-newswire.com/ens/mar2003/2003-03-17-01.asp>> viewed at 20 May 2006.

94 World Health Organization, *Water for Health: Taking Charge* (World Health Organization, Geneva, 2001), p.6.

95 Ibid p.10.

96 B. Menne and R. Bertolini, “The Health Impacts of Desertification and Drought”, *Down to Earth*, no. 14, 2 December 2000, pp. 4-6, 7.

97 A.J. McMichael, *Planetary Overload: Global Environmental Change and the Health of the Human Species* (Cambridge University Press, Cambridge, 1993); D. Pimental (et al), “Ecology of Increasing Disease”, *BioScience*, vol. 48, no. 10, October 1998, pp. 817-826.

Africa, health care services may be severely disrupted from population movements caused by droughts and desertification.<sup>98</sup> Droughts may also lead to an increase in the incidence of water and food-borne diseases because water shortages may leave people in developing regions no option but to use polluted and contaminated waters. Epidemics from water-borne diseases, such as cholera, typhoid, hepatitis A, diarrhoea and others, may then occur.

Desertification from climate change may also result in an increase in plant diseases, including wild plants, leading not only to food shortages but, in addition, further biodiversity decline. This illustrates the fundamental ecological principle upon which the ecological human health paradigm is based: namely, that human beings and all other organisms exist in a complete matrix of interrelationships where there are multitudes of positive and negative feedback mechanisms between environmental variables as well as numerous "chaotic" effects (these being effects where a small initial event gives rise to an unpredictably large final impact).<sup>99</sup> Scientific evidence shows that biodiversity decline has arisen from human disturbances to the structure and function of ecosystems and that human-induced global warming has been a significant cause of this. Disturbing the number of, as well as the existing interactions between, organisms has both direct and indirect influences on disease pathogens (organisms causing disease), vectors (organisms which transmit disease but don't necessarily contract the disease themselves) and reservoir organisms (those that serve as hosts for populations of pathogens).<sup>100</sup> In other words, because organisms are part of the "web of life", the distribution of organisms that cause disease is also affected by global warming. For example, the malaria parasite is transmitted from one human (a host) to another by mosquitoes (a vector). As mosquitoes require certain temperatures and humidity for proliferation, the incidence of malaria will be affected by climate change.

Deforestation can result in humans coming into contact with vectors that are normally contained to forests but which are displaced and settle in locations near humans. This has been seen in recent times in relation to the spread of diseases such as trypanosomiasis, Chagas disease, yellow fever, leishmaniasis and Kyasanur Forest Disease.<sup>101</sup> Deforestation may also result in a greater exposure of humans to vector-borne diseases, such as malaria, as a result of habitat changes that are favorable to increased growth of some species

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98 R.D. Kaplan, "The Coming Anarchy", *The Atlantic Monthly*, 273, February 1994, pp. 44-76; P.R. Epstein, "Is Global Warming Harmful to Health?", *Scientific American*, vol. 282, no. 2, August 2000, pp. 36-43.

99 D. Shearman, "Tide and Time Wait for No Man", *British Medical Journal*, vol. 325, 21 December 2002, pp. 1466-1468.

100 E. Chivian (ed.), Center for Health and the Global Environment, Harvard Medical School, *Biodiversity: Its Importance to Human Health: Interim Executive Summary* (Center for Health and the Global Environment, Harvard Medical School, Cambridge MA, 2002) at <[http://chge.med.harvard.edu/publications/documents/Biodiversity\\_v2\\_screen.pdf](http://chge.med.harvard.edu/publications/documents/Biodiversity_v2_screen.pdf)> viewed at 20 May 2006.

101 *Ibid* p.36. See also: R.S. Ostfeld and F. Keasing, "The Function of Biodiversity in the Ecology of Vector-Borne Zoonotic Diseases", *Canadian Journal of Zoology*, vol. 78, 2000, pp. 2061-2078.

of mosquito, such as *Anopheles darlingi*, as has occurred in Amazonia and South East Asia.<sup>102</sup>

Generally, under conditions of global warming, General Circulation Models (which are computerised models of climate used to make long-term predictions about climatic changes) that incorporate temperature-dependent vector reproduction, biting rates and reproduction rates of microorganisms, predict a spread of diseases by vectors into higher latitudes and higher elevations.<sup>103</sup> According to some researchers, malaria, yellow fever, dengue fever, tick-borne and mosquito-borne encephalitis are spreading to new geographical areas as a result of climate change.<sup>104</sup> These examples regarding deforestation, as well as those relating to desertification and drought, again demonstrate the direct links between global warming, ecological health and human health.

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102 Chivian (ed.), above n 100.

103 Ibid p.40.

104 Chivian (ed.), above n 100. See also: D.H. Molynaux, "Vector-Borne Infections in the Tropics and Health Policy Issues in the Twenty-First Century", *Transactions of the Royal Society of Tropical Medicine and Hygiene*, vol. 95, 2001, pp. 233-238.