Global health and climate change: moving from denial and catastrophic fatalism to positive action

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The health effects of climate change have had relatively little attention from climate scientists and governments. Climate change will be a major threat to population health in the current century through its potential effects on communicable disease, heat stress, food and water security, extreme weather events, vulnerable shelter and population migration. This paper addresses three health-sector strategies to manage the health effects of climate change—promotion of mitigation, tackling the pathways that lead to ill-health and strengthening health systems. Mitigation of greenhouse gas (GHG) emissions is affordable, and low-carbon technologies are available now or will be in the near future. Pathways to ill-health can be managed through better information, poverty reduction, technological innovation, social and cultural change and greater coordination of national and international institutions. Strengthening health systems requires increased investment in order to provide effective public health responses to climate-induced threats to health, equitable treatment of illness, promotion of low-carbon lifestyles and renewable energy solutions within health facilities. Mitigation and adaptation strategies will produce substantial benefits for health, such as reductions in obesity and heart disease, diabetes, stress and depression, pneumonia and asthma, as well as potential cost savings within the health sector. The case for mitigating climate change by reducing GHGs is overwhelming. The need to build population resilience to the global health threat from already unavoidable climate change is real and urgent. Action must not be delayed by contrarians, nor by catastrophic fatalists who say it is all too late.

Keywords: health; climate change; uncertainty

1. Introduction

Advocacy about the health consequences will ensure that climate change is a high priority. The United Nations Convention on Climate Change was set up in 1992 to ensure that nations worked together to minimize the adverse effects,

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but McMichael and Neira noted that, in preparation for the Copenhagen conference in December 2009, only four of 47 nations mentioned human health as a consideration [1]. With business as usual, global warming caused by rising greenhouse gas (GHG) emissions will threaten mass populations through increased transmission of some infections, heat stress, food and water insecurity, increased deaths from more frequent and extreme climate events, threats to shelter and security, and through population migration [2].

On the one hand it is necessary in the media to counter climate change sceptics and denialists, but on the other it is also important not to allow climate catastrophists, who tell us it is all too late, to deflect us from pragmatic and positive action. Catastrophic scenarios are possible in the longer term, and effective action will be formidably difficult, but evidence suggests that we do have the tools, the time and the resources to bring about the changes needed for climate stability.

2. Climate change evidence and denial

Given the current body of evidence, it is surprising that global warming and its causal relationship with atmospheric GHG pollution is disputed any more than the relationship between acquired immune deficiency syndrome (AIDS) and human immunodeficiency virus (HIV) infection, or lung cancer and cigarette smoking. The basic principles that determine the Earth’s temperature are, of course, relatively simple. Some of the short-wave solar radiation that strikes the Earth is reflected back into space and some is absorbed by the land and emitted as long-wave radiation (heat). Some of the long-wave radiation is trapped in the atmosphere by ‘greenhouse gases’, which include water vapour, carbon dioxide and methane. Without GHGs the Earth would be on average 33°C colder.

Over the last 150 years, since the Industrial Revolution, humans have been adding more carbon dioxide and methane into the atmosphere. The result is that the Earth’s atmosphere, ocean and land are indeed warming—due to increased atmospheric ‘greenhouse gas’ concentrations [3]. Gleick et al. [4], from the US National Academy of Sciences, wrote a letter to *Science* stating ‘There is compelling, comprehensive, and consistent objective evidence that humans are changing the climate in ways that threaten our societies and the ecosystems on which we depend’. The most recent report by the Intergovernmental Panel on Climate Change (IPCC) [5], amounting to nearly 3000 pages of detailed review and analysis of published research, also declares that the scientific uncertainties of global warming are essentially resolved. This report states that there is clear evidence for a 0.75°C rise in global temperatures and 22 cm rise in sea level during the twentieth century. The IPCC synthesis also predicts that global temperatures could rise further by between 1.1°C and 6.4°C by 2100, and sea level could rise by between 28 and 79 cm, or more if the melting of Greenland and Antarctica accelerates. In addition, weather patterns will become less predictable and the occurrence of extreme climate events, such as storms, floods, heat waves and droughts, will increase. There is also strong evidence for ocean acidification driven by more carbon dioxide dissolving in the oceans [6].
Given the current failure of international negotiations to address carbon emission reductions, and that atmospheric warming lags behind rises in CO₂ concentration, there is concern that global surface temperature will rise above the supposedly ‘safe limit’ of 2°C within this century. Each doubling of atmospheric carbon dioxide concentration alone is expected to produce 1.9–4.5°C of warming at equilibrium [7]. Of course, climate modelling is an extremely complex process, and uncertainty with projections relating to future emissions trajectories means that the time scale and magnitude of future climate change cannot be predicted with certainty [8]. These uncertainties are magnified when future climate predictions are used to estimate potential impacts. For example, the environmental impacts of climate change are also uncertain, but could underestimate such impacts because they detrimentally interact with habitat loss, pollution and loss of biodiversity due to other causes. There is also the additional problem that switching from biome to biome may not be directly reversible. For example, rainforest recycles a huge amount of water so it can survive a significant amount of aridification before it burns and is replaced by savannah. But the region then has to get much wetter before rainforest can return, as there is greatly reduced water cycling in savannah [9].

In the policy arena, further uncertainty surrounds the desire for international agreements on emission cuts, and the possible routes to such agreement and implementation. The feasible speed of technological innovation in carbon capture and provision of renewable/low-carbon energy resources is also uncertain.

Denying the causes or the current weight of evidence for anthropogenic climate change is irrational, just as the existence of ‘uncertainties’ should not be used to deny the need for proportionate action, when such uncertainties could underestimate the risks and impact of climate change. There is no reason for inaction and there are many ways we can use our current knowledge of climate change to improve health provision for current and future generations.

3. Catastrophism

At the other end of the scale are doom-mongers who predict catastrophic population collapse and the end of civilization. In the early nineteenth century, the French palaeontologist Georges Cuvier first addressed catastrophism and explained patterns of extinction observed in the fossil record through catastrophic natural events [10].

We know now of five major extinctions: the Ordovician–Silurian extinction (439 million years ago), the Late Devonian extinction (about 364 million years ago), the Permian–Triassic extinction (about 251 million years ago), the End Triassic extinction (roughly 199 million to 214 million years ago) and the Cretaceous–Tertiary extinction (about 65 million years ago). These mass extinctions were caused by a combination of plate tectonics, supervolcanism and asteroid impacts. The understanding of the mass extinctions led Gould & Eldredge [11] to update Darwin’s theory of evolution with their own theory of punctuated equilibrium. Many scientists have suggested that the current human-induced extinction rates could be as fast as those during these mass extinctions [12,13].
example, one study predicted that 58 per cent of species may be committed to extinction by 2050 due to climate change alone [14], though this paper has been criticized [15,16].

Some people have even suggested that human extinction may not be a remote risk [17–19]. Sherwood & Huber [7] point to continued heating effects that could make the world largely uninhabitable by humans and mammals within 300 years. Peak heat stress, quantified by the wet-bulb temperature (used because it reflects both the ambient temperature and relative humidity of the site), is surprisingly similar across diverse climates and never exceeds 31°C. They suggest that if it rose to 35°C, which never happens now but would at a warming of 7°C, hyperthermia in humans and other mammals would occur as dissipation of metabolic heat becomes impossible, therefore making many environments uninhabitable.

However, these studies do not take account of geological reconstructions. We know that during the Eocene some 50 million years ago global temperature was at least 5°C higher than today, with forests on Antarctica and rainforest extending as far north as Canada and as far south as Patagonia [20]. Some scientists argue that this was the golden age of life, as there could have been at least twice as much living biomass on the Earth as today. At the beginning of this period, there was an extreme period of global warming called the Paleocene–Eocene thermal maximum when global temperatures were at least another 5°C warmer [21,22]. This did lead to some extinction in the oceans but it was not the end of life on the planet nor did mammals suffer mass extinctions.

So, while history suggests that imminent catastrophe is as false as climate change denial, it could be as big a threat to action. Catastrophic speculation, especially when based on limited evidence and without specific time frames, may induce an unnecessary sense of fatalism and helplessness when, in the shorter term, there is a huge scope for positive action.

In this paper, we address some of the specific questions raised by catastrophists, why there is still room for optimism, and how a compelling and feasible case can be made for practical action in the next two decades to bring about climate stabilization and appropriate management of threats to health.

4. Managing the health effects of climate change

The UCL Lancet Commission articulated a strategy to manage the health effects of climate change that involves three broad areas of action (table 1). Further, the Commission described a broad framework that can be applied to these strategies to guide action (table 2). Although climate change represents an unprecedented challenge to global governance, intelligent and effective actions are possible, although delay is not an option [4]. In the following discussion we focus on the priorities and potential for urgent action.

(a) Health promotion to reduce greenhouse gas emissions

The health sector could play a more prominent and effective role in lobbying for the reduction of GHGs. Three critical questions for mitigation, which should inform health promotion, are whether we can afford to reduce GHGs by 80–90% by 2050 without severe economic recession or depression, whether the
promotion of health benefits from reducing GHG emissions
address pathways through which climate change leads to ill-health, to increase resilience
  — communicable disease
  — heat stress
  — food insecurity
  — water insecurity
  — vulnerable shelter and settlements
  — extreme climatic events
  — population migration
strengthen health systems
  — early warning of public health and poverty-related problems
  — lowered carbon footprint
  — measuring the environmental impact of health interventions
  — promotion of low-carbon lifestyles

Table 2. A framework for policy and action to tackle the health effects of climate change.

informational
  more information at global, national and local levels
poverty and equity related
  an accelerated drive to address poverty and equity
technological
  new approaches to food and water security, prevention of disease, better buildings and reducing vulnerability in poor communities
sociopolitical
  stronger social and political engagement developing low-carbon living
institutional
  greater coordination and accountability by governments and international institutions to address the health effects of climate change

technology for renewable energy will come on-stream quickly enough to achieve these ambitious goals, and what are the health co-benefits to accrue from a low-carbon lifestyle?

(i) Will the transition to low carbon be unaffordable and/or associated with unacceptable austerity?

There are two major elements to the economics of a global low-carbon transition: the investments and expenditures that will need to be made by industrial countries to transform their energy systems so that they emit less than a fifth of their current carbon emissions by 2050 (to which the UK is committed through the Climate Change Act) and decarbonize totally soon thereafter; and the financial transfers that richer countries will need to make to industrializing countries to ensure that their industrialization is powered to an increasing extent by low-carbon energy.

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The Copenhagen Accord, signed by many countries at the Copenhagen Climate Summit in December 2009, accepted the need to keep the average global temperature increase over pre-industrial levels to 2°C in order to avoid the risk of dangerous anthropogenic climate change. There is roughly a 50 per cent chance of achieving this if atmospheric concentrations of greenhouse gases can be kept to 450ppmv [23, p. 220], a rather small increase over the current level of around 430ppmv. To keep within 450ppmv, global emissions will need to peak before 2020 and be no more than 70 per cent of their 2005 level by 2050 [23, p. 227]. Given that developing countries are certain to increase their emissions substantially above today’s level before they stabilize, this implies a minimum cut of 80 per cent in industrial country emissions by 2050. The further emissions rise over 2010–2020, the larger this cut will have to be to achieve the 450ppmv goal, until eventually it would become infeasible, and a greater than 2°C average rise in global temperatures would become likely.

Given the scale of the changes in question, and the time scale over which they will come about, the only way to gain insights into the kinds of economic and energy trajectories involved is through sophisticated energy and economic modelling of the kind employed by the International Energy Agency in its \textit{World energy outlook} [24] and \textit{Energy technology perspectives} [25] series, and by many economists and economic research institutes, often grouped in international comparison projects such as the Stanford Energy Modeling Forum (see \url{http://emf.stanford.edu/}) or the Innovation Comparison Modeling Project (IMCP, see \url{http://www.econ.cam.ac.uk/research/imcp/}).

The results from modelling exercises of these kinds are clearly replete with uncertainties of all kinds, of which two of the most important are the development of the cost and performance of different low-carbon technologies over coming decades. On the basis of best estimates of parameters of these kinds, a large number of modelling scenarios of different levels of decarbonization of national energy systems and of the world energy system as a whole have been constructed.

Figure 1 shows the results of a meta-analysis of the costs, in terms of gross domestic product (GDP) foregone, of achieving different levels of carbon reduction from a baseline specified in the model. It can be seen that, according to these model runs, cuts of 80 per cent in emissions could cost as much as 6 per cent
of GDP, but the great majority of the estimates fall within a cost range of 1 to 4 per cent of GDP. While not insignificant, such a cost does not seem unreasonable as an insurance against incurring costs of up to 20 per cent of GDP [23, p. 188], with even higher costs possible should climate change result in widespread social disruption and conflict.

Such estimates of costs tend to depend on the assumption that governments adopt cost-effective policies to achieve a low-carbon transition, and, to the extent that they do not, costs could be higher. There is a general agreement, among economists at least, that a crucial component of any cost-effective policy mix will be a significant carbon price, established through either a carbon tax or an emissions trading scheme. A policy approach that seems to have much to recommend it is environmental tax reform (ETR)/green fiscal reform (GFR), which entails the shifting of taxation from goods (like income and profits) to bads (like resource use and pollution). Recent research has suggested that, using ETR, the European Union could achieve a unilateral 20 per cent emissions reduction from 1990s level at very low or no economic cost and with an increase in employment [27].

In addition to essentially decarbonizing their own energy sector, industrial countries will have to make the resources available for developing countries to grow in low-carbon ways. The Copenhagen Accord envisaged new funding streams of $30 billion per year by 2012 and $100 billion per year by 2020. This is, of course, a small fraction of the sums spent by industrial countries in 2008–2009 to shore up their banking systems, and could easily be afforded. But actually mobilizing the resources and agreeing the channels through which they should flow to the countries concerned is proving far from easy. There is an urgent need to make progress on the kinds of practical institutional issues related to this financing, discussed by, for example, Müller [28].

(ii) Do we have the technology and potential innovation to switch from fossil fuels to renewables?

Low-carbon options for a sustainable energy future are addressed in this issue in papers by Armstrong [29], Jones [30] and Peter [31]. The evidence from the corporate sector suggests that, despite insufficient investment in environmental projects from recent global stimulus spending, we may have reached a tipping point in the economics of green energy. The International Energy Agency says that $10 000 billion of investment will be needed globally over the next 20 years, but, with plausible assumptions about fossil fuel prices, 86 per cent of this should be offset by fuel savings [25]. The net balance of $1.4 trillion is less than half the global bail-out. There has been a steady increase in private equity funds and investments by retail companies in green production, and major emerging market countries like China, Brazil and India have invested in low-carbon future technology. The World Bank is financing a project called Lighting Africa using light-emitting diodes to provide an alternative to polluting kerosene lamps, which is a surprisingly large market. In Brazil, the government has set deforestation reduction targets; and, in India, government subsidies have supported the growth of a wind power industry. Intellectual property is a major issue: a green TV channel in the USA, UK and Australia means that new ideas can get to market faster.
(iii) Will the health co-benefits of low-carbon living act as a major incentive to individual and societal behaviour change?

A recent *Lancet* series showed that many measures to reduce GHG emissions in household energy, transport, food, agriculture and electricity generation have substantial health benefits [32,33]. Major health problems will be addressed through mitigation, such as child mortality from acute respiratory infections, ischaemic heart disease in adults, and other non-communicable diseases such as obesity, diabetes and depression. To achieve mitigation with a health dividend, policy-makers will need to prioritize increased active transport (walking and cycling) and reduced private-car use in urban settings, increased uptake of improved cooking stoves in low-income countries, reduced consumption of animal products in high-consumption settings, and generation of electricity from low-carbon sources rather than from fossil fuels, particularly coal [32–36]. Health co-benefits should be taken into account in international negotiations about the costs of mitigation.

Nonetheless, there is little evidence available that individual behaviour change in high-consuming countries can be achieved at scale without strong government policy and incentives. Health professionals will have an important role in the design of a low-carbon economy, and the promotion of evidence of the benefits to public health.

(b) Tackling the pathways linking climate change to ill-health

(i) Will populations succumb to heat stress?

Human populations live and survive in temperature above 40°C and many groups are well adapted to these temperatures. There are recent concerns from Sherwood & Huber [7, p. 9952] about exceeding 35°C for extended periods, which should induce hyperthermia in humans and other mammals, the risk rising sharply with global-mean warming of about 7°C, calling the habitability of some regions into question. With 11–12°C warming, such regions would spread to encompass the majority of the human population as currently distributed.

Nonetheless, the veracity of this projection will depend on what is meant by ‘extended periods’, as humans can tolerate short periods of intense heat exposure. Certainly, climate change may reduce work capacity in heat-exposed jobs and lead to greater difficulty in achieving economic and social development in the countries affected [37]. The authors show that work capacity rapidly reduces as the wet-bulb globe temperature exceeds 26–30°C, and this measure can be used to estimate the impact of increasing heat exposure as a result of climate change in tropical countries. Certainly, investment in strategies to reduce heat stress through better occupational management of risk, and better ventilation in buildings, is a high priority. European heatwaves have led to thousands of deaths, especially among elderly people, and health and social-care systems need to adapt now to design buildings and infrastructure to reduce health impacts [38]. To date, in the UK, excess deaths ‘saved’ from warmer winters are probably greater than deaths from heatwaves. Mitigation strategies for housing insulation to reduce fuel consumption can also be designed to reduce summer heating.
(ii) Will the spread of infectious diseases cause major increases in population mortality rates?

While the transmission rates of vector-borne diseases, e.g. arboviruses, Dengue and malaria, may increase and the geographical spread of these diseases will be extended, there is no reason why control measures as part of good public health should not limit the size and case fatality rates of epidemics. Malaria control is a good example of why increased transmission risk does not necessarily mean increased population fatality rates. Even in highly endemic populations, wealthier households can minimize risks of infection by reducing exposure to vector bites through use of repellents, sprays and insecticide-treated bednets, and by ensuring prophylaxis in pregnancy; and rapid case management with effective artemisinin-based combination drug therapy can reduce the risk of resistance. Snow & Marsh [39] report that, with improvements in the coverage of these measures since the Abuja Declaration a decade ago, clinical malaria incidence has fallen sharply at many sites in Africa over the past decade. Predictions of an intensification of malaria in a warmer world must be considered against a century of warming that has seen marked global declines in the disease [40].

The biggest population threat from infectious disease probably comes from unknown emerging infections crossing from animal reservoirs to man, a risk that will increase with dilution of animal reservoirs through species elimination, or through increased proximity of humans and wild animals from loss of habitat [14,41–43].

While the biggest pandemic of modern times, HIV/AIDS, an unusually difficult virus to control, has killed over 25 million people since 1981 [44], massive population collapse from climate-induced pandemics of food poisoning, cholera or vector-borne disease seems unlikely.

(iii) Will reduced food production increase the risk of hunger and famines?

The risks from climate change for food production include reduced crop yields, increased pests, drought or too much rainfall at the wrong time, and increasing water and land scarcity.

The amount of arable land per person worldwide has halved to about 0.2 ha over the past 40 years owing to population growth and increased demand for food [45]. Further, the economic effects of rising prices for food, oil and fertilizers could sharply increase the number of the chronically hungry, currently estimated at over 1 billion people. By the latter part of this century, there could be an increase in the current global population to 9 billion, and some authors have projected large reductions in crop yields using current systems and standards for agriculture [46,47].

But there are many reasons to be more optimistic if there is positive action and investment in agriculture, food management, poverty alleviation and family planning. First, Malthusian predictions of calamity have repeatedly failed to materialize. Amartya Sen has highlighted the fact that famine is often related to a household’s inability to command entitlements to food, through falling incomes or rising prices, rather than because food is unavailable [48]. Current economic growth rates of 8–9% in India and 5–6% in Africa promise greater resilience for many countries, and greater investments in agriculture.
Second, the food security challenge in India illustrates how progressive policy options are the first priority to counteract limitations in food production. Since 2000, the per-hectare yield of wheat, rice and cereals in India has declined after showing an upward trend for five decades [49]. Pulse consumption in poor rural households, which have not benefited from national economic growth, has fallen from 27 kg per head in the 1960s to 11 kg per head. As part of a National Food Security strategy, the Public Distribution Scheme, whereby households below the poverty line are entitled to 35 kg of grain each month at 1–2 rupees per kilogram, is an attempt by the government to compensate for the cessation of the green revolution and a growing rural crisis [50]. Implementation has been patchy, and a comprehensive Food Security Act would cost around $20 billion per year, which is expensive but substantially lower in cost, for example, than other Indian tax exemption schemes. Dreze [50] suggests that the government introduces the scheme in the poorest third of districts, and extend it gradually.

Third, there is also much scope for a green revolution in Africa, where only 4 per cent of the land is irrigated compared with 40 per cent in South Asia, and where crop farming uses 10 times more land per tonne of crop than in the UK [51]. Recent evidence from Malawi shows that strong governance allied to investments in fertilizer, seeds and treadle irrigation pumps has produced dramatic increases in crop yields such that the country now exports food to Zimbabwe and Kenya [52].

Fourth, Conway & Waage [51] describe the potential for new seeds that are drought- or flood-resistant and increased production in new areas; and cheaper access to desalinated water through nanotechnology (developed by researchers at Lawrence Livermore National Laboratory in the USA) could reduce costs of desalination by 75 per cent. Using concentration gradients from technology developed by a Canadian company, Saltworks, reported in the Economist [53], 1000 litres of fresh water might be produced with less than 1 kWh of electricity compared with 3.7 kWh used by the current best reverse osmosis plants.

Finally, a new Royal Society series has reviewed progress and challenges with the future of the global food system, and concludes that there are grounds for optimism because of ‘the high likelihood of population and consumption demand reaching a plateau some time during this century, and the major opportunities for yield growth through the application of traditional and novel science’ [54, p. 2776].

(iv) Is population growth a major threat to mitigation?

Population stabilization is not the primary solution to GHG emissions, which require cuts in the high-consumption, high-fossil-fuel-using and population-stable countries. But global investment in aid for family planning programmes in poor countries fell to a derisory $300–400 million annually during the Bush administration because of US antagonism through the ‘Gag Rule’ (formally the ‘Mexico City Policy’) to abortion and family planning programmes [55], but also perhaps due to the diversion of funds to vertical HIV programmes. The ‘Gag Rule’ was repealed early in the Obama presidency. Now the developing world needs renewed commitments to better education and to programmes to reduce the mortality of mothers and children, combined with investment in family planning and to protect women’s reproductive rights. Investment in mother and newborn
health at $1.3 billion remains absurdly low compared with sums invested in insolvent banks [56]. Stabilization of population within a generation is possible. China, Bangladesh, southern India, Latin America and countries in North Africa provide examples for sub-Saharan African countries to emulate, and Rwanda is an early example of success [57]. There is also the prospect that, after peaking mid-century, population stabilization and the onset of a decline are likely [58].

(v) Will water insecurity lead to political conflict?

Water shortages may have a major effect on food production as increasing demand for agriculture competes with domestic and commercial consumers [59]. Water is also essential for ecosystem services, and environmental flow requirements for fisheries, lakes, groundwater reserves and aquifers. Competition from other sectors is likely to be more important than climate change for water security in the current century.

There is little doubt that water insecurity and stress will increase cross-border tension in vulnerable areas. Recently, proposed dams in India have led to protests from Bangladesh; the threat of diversion of the Brahmaputra river on the Tibetan plateau to boost river flows in China has raised concerns in India; China’s hydroelectric dams along the Yangtze upstream have raised concerns from Vietnam and Cambodia; and Turkey’s decision to build dams along the upper Euphrates has been challenged by Syria. Nonetheless, there is no hard evidence that water disputes have ever led to war [60]. Such matters can be solved by international agreements and strong diplomacy.

(vi) Will extreme weather events threaten large-scale population survival?

Extreme weather events are important not just for their potential impact on mortality, but also for morbidity, long-term impacts on social disruption, mental health and infrastructure damage and effects on long-term development. The 2010 floods in Pakistan provide a good example of such a disaster.

Several peer-reviewed studies show a clear global trend towards increased intensity of the strongest hurricanes over the past two or three decades [61,62]. The strongest trends are in the North Atlantic Ocean and the Indian Ocean. According to the 2007 Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC-AR4), it is ‘more likely than not’ [greater than even odds] that there is a human contribution to the observed trend of hurricane intensification since the 1970s. In the future [5, p. 46], ‘it is likely [greater than 2 to 1 odds] that future tropical cyclones (typhoons and hurricanes) will become more intense, with larger peak wind speeds and more heavy precipitation associated with ongoing increases of tropical [sea surface temperatures]’.

Fatality rates during extreme weather events are related to vulnerability and the socio-economic status of a population at risk. In Bangladesh, cyclone mortality has fallen dramatically over the past three decades as the country has developed and implemented early warning systems, cyclone shelters and rapid responses to extreme climate events. Further investment to reduce risk is likely to be highly cost-effective [63] and demonstrates the importance of investing in both mitigation and adaptation strategies to reduce the impacts of inevitable climate change so that vulnerability can be reduced and resilience increased.
In summary, extreme climate events are likely to increase in intensity and frequency, but economic growth and development should reduce population vulnerability.

(vii) Will rising sea levels cause mass migration and a major threat to coastal cities?

Beyond 2100, if climate change proceeds unchecked, accelerating loss or displacement of the Greenland and Antarctic ice sheets will cause many metres of sea-level rise (perhaps 4 m or more by 2200) and will be a major threat to many of the world’s coastal cities, including London and New York [64]. In this century, however, sea-level rise is likely to be steady, predictable and with a probable maximum of 1–2 m rise by 2100 [64]. Within 50 years it will threaten low-lying areas such as Pacific islands, the Maldives and up to 20 per cent of the land-mass of Bangladesh, currently housing up to 20 million people. Nonetheless, in assessing future effects, it is important to remember that the economic strength and vulnerability of nations will change. In Bangladesh, over the past three decades, the economy has grown steadily, and fertility and child mortality rates halved, with impressive improvements in education indicators. Managed migration from flood-affected areas, increasing urbanization and adaptive responses to agricultural management will present governance challenges that are formidable but not insuperable. A major adaptation response is to develop the best strategies for reducing flood risk and flood management. This includes planning issues around development of cities, not building on floodplains, water management, land use, choices about investment in flood defences and making the best ‘no-regrets’ decisions for the future.

The longer-term outlook over the next 300 years is much more worrying. In the Pliocene period, about 3 million years before present, when global temperatures were about 3°C higher than now, the sea level was 25 ± 10 m higher than today [65]. Long-term maintenance of atmospheric CO₂ above 350 ppm (lower than current levels) could result in a much higher sea level, as happened at the end of the last Ice Age when temperatures rose by 4–7°C and sea level rose by 120 m [64]. Such effects could have devastating effects on geography and the global economy, and would cause mass population migration, but over an extended period of time.

(c) Strengthening public health systems

In addition to reducing our emissions of GHGs through mitigation strategies, we must also prepare for the inevitable climate changes to which we are committed as a result of previous emissions. Adaptation is not an alternative to mitigation, and has generally received less attention than mitigation, but it is essential to ensure that actions are taken to reduce vulnerability and increase resilience of societies to current and future impacts of climate change. The 2010 floods in Pakistan and the heatwave in Russia are examples of how extreme weather events can impact millions of people locally, and food supplies internationally. Those at greatest risk of impacts are the most socially and economically disadvantaged. It follows that adaptation plans need to protect the most vulnerable, to reduce inequalities and to implement strategies that are consistent with the principles of sustainable development [66].
In the UK, legislation is in place for both adaptation and mitigation. The Climate Change Act 2008 introduced legally binding targets to cut emissions of GHGs by at least 80 per cent of the 1990 baseline by 2050. An Adaptation Sub-Committee (ASC) set up under the Act provides advice to Government and devolved administrations on the risks arising from climate change, and how to monitor the UK’s preparedness to deal with the consequences of a changing climate. The Department of Health [67] has recently published its plan for both mitigation and adaptation, which sets out aims for reductions in carbon emissions, reviews impacts on health, reports on actions to date, and discusses risks and priorities. These include the built environment, service design and delivery, information communication technology, workforce, research, finance and procurement. The National Health Service (NHS), Health Protection Agency and UK public health authorities have a major role not only in emergency response to extreme events, but also in building sustainable health-care facilities and infrastructure fit for and resilient to future climate impacts. By measuring and reducing their carbon footprint, measuring the environmental impact of interventions, reducing patient travel, and working towards sustainable procurement of goods and services, the NHS can reduce carbon emissions [68]. Health practitioners and consumers can also play an active role in this process [69].

In many poorer countries, health systems are fragmented, with little in the way of coherent, population-based and bottom-up health planning. They must not only deliver effective, efficient and equitable clinical services in settings resilient to climate impacts, but also provide effective public health responses to climate-induced threats to health. Health facilities act as early warning systems for epidemics and nutritional deterioration, so investment in health systems to achieve the United Nations’ Millennium Development Goals is also a longer-term investment to manage the health effects of climate change. Weak health governance and management structures in developing countries require long-term investment in human capacity. Recent data suggest that progress towards the Millennium Development Goals has been mixed, and there is a significant group of countries where progress has been absent or very poor [70]. Social inequalities in health outcomes remain the major challenge [66] and reduction in health inequalities is a key element of reducing population vulnerability to climate change.

Health promotion of low-carbon lifestyles is probably the biggest single challenge of all. Incentives and legislation to change behaviour will need to be effective and on a large scale, but must not alienate electorates. Research to explore the costs and health benefits of interventions that affect low-carbon living at scale is one of the highest priorities for managing the health effects of climate change.

5. Conclusion

The case for action to reduce climate change is overwhelming and the global health threat from it is real and urgent. Action must not be delayed by contrarians, nor by catastrophic fatalists who say it is all too late. The health sector has not been sufficiently prominent in the mitigation or adaptation
debate, nor in the promotion of the health benefits of a low-carbon future. Building the resilience of populations to tackle the pathways by which their health will be threatened requires large increases in national and international investment. Climate change presents an enormous political and governance challenge, with a need for greater information, poverty reduction, investment in new technologies, a transformation in social and cultural behaviour and new integrated international governance structures. Strengthening health systems is a central part of this process.

References

18 Lovelock, J. 2006 The Earth is about to catch a morbid fever that may last as long as 100 000 years. The Independent, 16 January 2006.


23 Stern, N. 2008 *The economics of climate change: the Stern Review*, p. 120. Cambridge, UK: Cambridge University Press.


26 Barker, T., Qureshi, M. S. & Köhler, J. 2006 The costs of greenhouse gas mitigation with induced technological change: a meta-analysis of estimates in the literature. Tyndall Centre for Climate Change Research, Working Paper No. 89. Tyndall Centre, University of East Anglia, Norwich, UK.


Global health and climate change

50 Dreze, J. 2010 The task of making the PDS work. The Hindu 8 July 2010.
68 NHS Sustainable Development Unit. 2009 Fit for the Future. See http://www.sdu.nhs.uk/publications-resources/4/Fit-for-the-Future-/